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SANITARY TRAINS.

As an annex to the experiments that interested the art of war, properly so called, the mobilization of the 17th army corps gave rise to various trials of *materiel* for troops in the field, and, among others, to experimentation with a sanitary train, which some of our readers may have examined last summer on the side tracks of the Western and Paris Railroad.

The sanitary train is not, as might be thought, a movable hospital. It could not, for example, be compared with boats which are arranged for the reception of wounded soldiers, and upon which the latter may be either transported or kept in safety, far from the field of battle, in case of a crowding of the hospitals. The true role of the sanitary train consists in taking as large a number of wounded as possible from the crowded hospitals and carrying them to hospitable establishments in the interior of the country, where they may receive the care required by their condition for as long a time as necessary. Planned in view of a rapid and continual service, the train had to be arranged in a complete enough manner to receive patients that are dangerously wounded, and that consequently require care at every moment during the journey. It was necessary, moreover, that it should furnish them a certain degree of comfort, so as not to aggravate their condition during a trip that may be of some length.

A few words on the history of this humane arrangement: The first nearly satisfactory experiments on the carriage of wounded soldiers on railways date back to 1881. At this epoch, the experiment chiefly concerned the mode of suspension of the stretcher designed to receive the patient, and which was devised in this case by Col. Bry. Although instructive, the experiment did not prove conclusive, and Col. Bry's system, which was rejected for permanent sanitary trains, was adopted only for improvised ones.

New experiments were made in 1884, and the outcome of these was that the special committee on sanitary trains gave out the following definitive programme:

1. As the mode of suspension of the stretchers placed in the cars is not satisfactory for the carriage of dangerously wounded or sick soldiers, an elasticity sufficient to prevent jarring and shock must be required in the suspension of the vehicle itself.

2. The number of wounded must not be greater than eight to the car, and the beds must be placed in the corners of the car, and spaced in a vertical direction in such a way as to allow the patient to assume a sitting posture and the surgeon to dress his wounds.

3. Communication between the cars must be had by means of a central passageway.

4. Ventilation must be secured through movable windows at the ends of the upper roof of the car; and for night, each car will be provided with a night lamp and a lantern of the military type.

5. As heating by cylinders of hot water is recognized as insufficient, recourse must be had to small stoves.

6. The floor of the cars will be covered with linoleum.

7. A special car furnished with iron bedsteads with curtains, a *lavabo*, some seats, a bureau, and a stove, will be set apart for the surgeons.

8. A special car will be set apart for the nurses, and the furniture will comprise a table bureau and some seats.

9. A special car for the kitchen will contain a range, water tanks, tables, and closets for the plates and dishes, and will serve for the preparation of food and diet drinks.

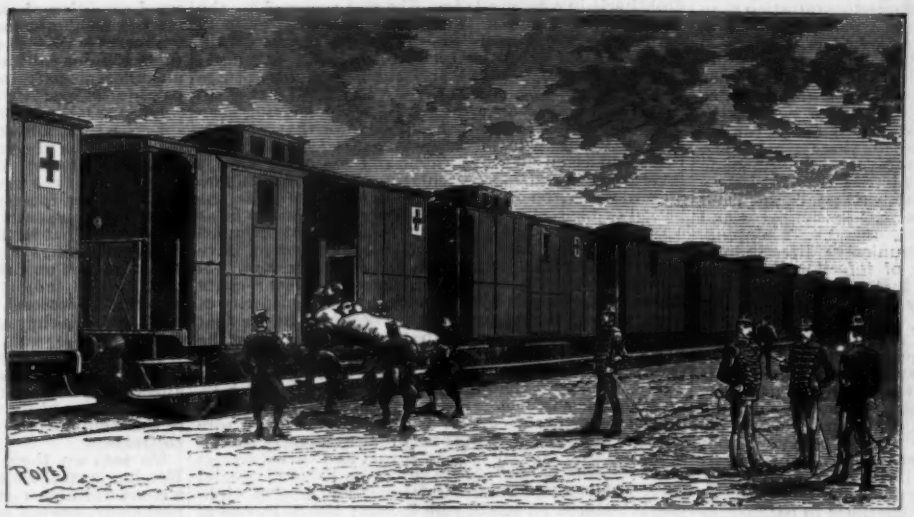


FIG. 1.—PUTTING A WOUNDED SOLDIER INTO A SANITARY CAR.

FIG. 2.—INTERIOR OF A SANITARY CAR.

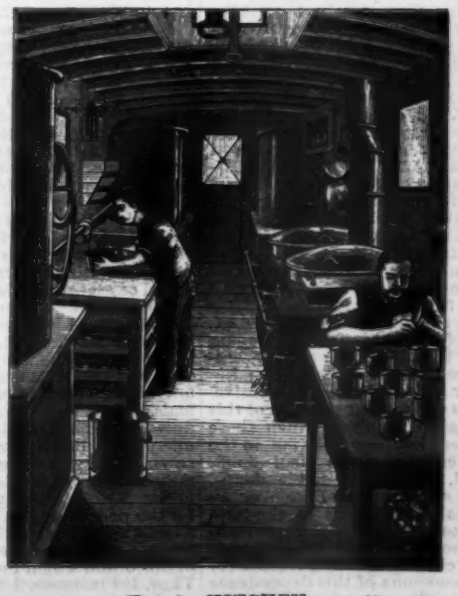


FIG. 3.—KITCHEN.

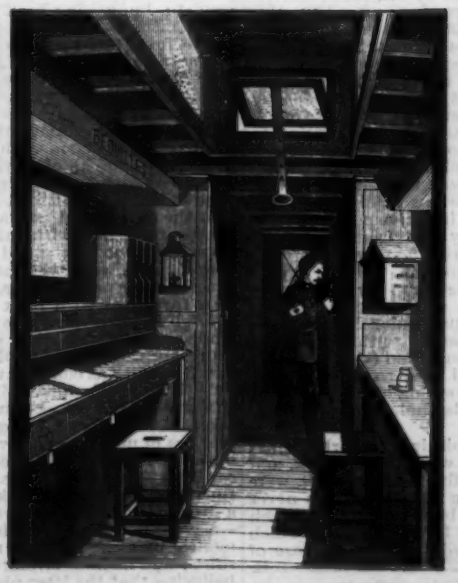


FIG. 4.—DISPENSARY.

10. A specially arranged car will be reserved for the dispensary, the linen, and the surgical instruments.

Finally, as for the front and rear cars, the former of these, provided with a closet, will carry a stock of provisions, and the latter will be reserved for soiled linen and for fuel. These two cars, which do not communicate with the others, will carry the guard and be provided with lookouts and brakes.

11. The entire sanitary train will comprise 22 cars, thus distributed: 16 for the wounded, 1 for the surgeons, 1 for the attendants, 1 for the kitchen, 1 for medicine, instruments, and linen, and 1 rear and 1 front car.

The Western Railroad Company, under the direction of Mr. Clevault, engineer in chief of rolling stock, undertook a study of this programme, and the result was the construction of the train that we are describing.

The type of car selected is the baggage car for fast trains. As its mode of suspension upon springs of a flexibility of 38 mm. is deemed insufficient, measures have been taken, in case of mobilization, to substitute for these springs others whose flexibility will reach 90 mm. In this way, jarring on the trip, even when the train is running at a great speed, will no longer be perceptible except on passenger cars of the first class. The other prescriptions of the committee have been executed by the company in concert with the health service. The arrangement of the cars for the surgeons, hospital steward, and cook have been well studied with a view to a rational utilization of the space disposable. A single important modification has been made in the programme as regards the kitchen. It having been found that the latter was not sufficiently capacious, it was decided to add another car, thus raising the total number to 23.

The role of the railroad company stops at this study and construction. Through simple and ingenious arrangements, it has succeeded in furnishing the service of war a *materiel* which, apart from the sanitary service, remains perfectly adapted to the needs of the ordinary freight traffic of the road. The internal equipments of the cars designed for the carriage of the wounded have been so arranged that they can be easily and quickly put in working order. According to the data of the programme, each corner of the car is provided with a frame of varnished wood capable of receiving two beds, one above the other. These frames rest upon the floor of the car through the intermedium of several thicknesses of Wilton carpet, so as to still further isolate them from shocks. The beds are formed of strong canvas fixed to the wooden frame by suspension belts, thus still further increasing the elasticity of the bed. It only remains to place a mattress and some bed clothes upon the canvas. Every patient has within his reach a small flanged shelf fixed to the frame by hooks, and designed to receive a cup and a pot of diet drink and other medicaments. Finally, the equipment of each car is completed by small objects such as seats, thermometers, stoves, etc.

In addition to the doors at the end of the cars that allow of communication between one end of the train and the other, the cars are provided with wide side doors for the reception of the patients.

The first sanitary train was

experimented with on the 4th of July, 1887, on the trip from Paris to Havre and return, at a mean speed of from 18 to 24 miles per hour. Eighty-eight infantry soldiers, simulating wounded men, were laid upon stretchers and carried to one of the cars, where thirty nurses attended them. During the trip the kitchen range was lighted, and as, very happily, the "wounded" were all in good health, they were able to do justice to the breakfast that was served to them, and the bill of fare of which was much superior to their usual one. It resulted from this experiment that the organization of sanitary trains no longer offers any unforeseen difficulties, and that a great humanitarian progress has been accomplished. A quick and easy emptying of overcrowded hospitals near a field of battle is hereafter assured, and, with the exception of a few slight modifications, the type of sanitary train presented by the Western Railway Company has consequently been adopted by France. Ten trains after this model will soon be ready to run upon our system of railways.—*La Nature.*

ETIOLOGY OF SCARLET FEVER.*

By Dr. E. KLEIN, F.R.S.

AMONG the infectious or zymotic diseases there are two at any rate (namely, scarlet fever and diphtheria) of which it may be said that their spread is to a lesser extent dependent on defective domestic sanitation than is the case with some of the other zymotic diseases, as, for instance, typhoid fever. Indeed, it is maintained by competent authorities that scarlet fever and diphtheria do not invade the houses of the poor with faulty sanitation with greater frequency or with greater severity than those of the well-to-do, however perfect the sanitary arrangements. This view is based on the important experience gained during the past twenty years, viz., that epidemics of scarlet fever and diphtheria have been brought about by milk. I may here state by way of explanation that a fact well established, and needing no further comment, is that scarlet fever and diphtheria are, like small-pox, measles, whooping-cough, and typhus fever, communicable directly from person to person. This mode of infection, doubtless an important one, and coming into operation in single cases wherever the elementary rules of isolation and disinfection are transgressed, altogether sinks into insignificance when compared with the infection produced on a large scale if a common article of diet like milk should become in some way or another the vehicle of contagium, as has been proved to be the case in a number of epidemic outbreaks. These epidemics, known as milk scarlatina, milk diphtheria, and I may add also milk typhoid, have this in common, that almost simultaneously, or at any rate within a short time, in a number of houses, having no direct communication by person or otherwise with one another, there occur sometimes singly, sometimes in batches, as it were, cases of illness: scarlet fever, diphtheria, or typhoid fever, as the case may be. And it was this peculiar character which pointed to a condition which must have been common to all these households. On closer examination it was indeed found that all these households had this, and only this, in common—that they were all supplied with milk coming from the same source, that is to say, from the same dairyman. Other houses supplied with milk from a different source escaped; and further it was shown that, as soon as the consumption of the suspected milk ceased also, the the epidemic, as such, came to an end, except, of course, the cases due to secondary infection from person to person. The medical department of the local government board have had for years past their attention fixed on these milk epidemics, and in the reports of the medical officer many of these are described with great detail. Among these, Dr. Ballard's report in 1870 on enteric fever in Islington, Dr. Buchanan's in 1875 on an outbreak of scarlet fever in South Kensington, and Mr. Power's on an outbreak of scarlet fever in St. Giles and St. Pancras in 1882, are specially to be referred to. Mr. Ernest Hart has tabulated all the outbreaks of milk epidemics that have been investigated until 1881, in vol. iv. of the "Transactions of the International Medical Congress for 1881." Now, analyzing these outbreaks as far as they refer to scarlet fever, there are several of them where the assumption that the milk acquired the power of infection by contamination from a human source cannot be excluded. This infection, if proved, would stand on the same footing as if due to contagion from person to person, for it is clear whether the contagium is conveyed from one person to another by air, food, drink, or other articles, it always remains contagion from person to person. Now, in some of the epidemics tabulated by Mr. Hart, and recorded by subsequent observers, *i. e.*, after 1881, this mode of milk contamination cannot be excluded, as I said before; but comparing the dates when the milk might be supposed to have become so contaminated with the dates when the milk has actually produced infection, it will be found that a certain discrepancy exists, and as will be shown later, another mode of infection, viz., from a person affected with scarlatina to the cow, and through the cow to the milk, and then to human beings, cannot be excluded either. There are other epidemics recorded in these tables, in which the mode of infection of the milk is not ascertained; and in a third set the milk acquired infective power in some way or another, but certainly not from a human source. As an illustration of the first group of epidemics, *i. e.*, probable contamination from a human source, I will refer to the table given by Mr. Ernest Hart.

Now, mark this, that on one particular day the fever broke out. We will return presently to this point.

As an illustration of the second kind (viz., probably not from a human source), I will refer to the outbreak of scarlet fever in Oxford in the spring of 1882, recorded by Dr. Darbishire in the St. Bartholomew's Hospital Reports, vol. xx.

The substance of Dr. Darbishire's report is this: Three cows were kept by those who sold the milk, and nine houses, containing eighty-five persons in all, were supplied morning and evening; the milk was never stored, as there was generally barely enough at each milking for all the customers. In the house to which the cows and paddock belonged, there was a case of

1881, April.	Keswick.	J. Robertson, M.D., M.O.H.	A dairy closely adjoined a house where scarlet fever had existed for several weeks. The cows were milked, every night and morning, into an open tin can carried across an open yard past the affected house.	The children who first caught scarlet fever in the locality played about the yard while in a state of desquamation.	On one particular day a general epidemic of scarlet fever broke out in the town, between thirty and forty families being invaded. All those suffering from the disease received their milk supply from this particular dairy farm. Some member of every family supplied had either a scarlatinal sore throat or scarlet fever on this day. Other families supplied from a different source escaped the disease.	A lodger had the milk raw for supper and was attacked. His landlady boiled her milk the same night and escaped.

diphtheria in a young lady. She was removed to the infirmary on March 1. The cow man had a child ill with scarlet fever in his cottage from February 27 till March 3. On March 3, Dr. Darbishire had this child removed to the hospital and the cow man's cottage thoroughly disinfected. The cow man left his cottage to sleep in lodgings near, the care of the cows having been handed over to another man, engaged for that purpose. Now, if the milk had become infected from either of these two cases (one diphtheria and the other scarlet fever), this must have occurred for the first before March 1, for the other before March 3; and as the period of incubation of scarlet fever is known to be as a rule less than seven days, it follows that, March 3 being the last day on which the milk could have received the contagium from a human being, March 10 would be the last day on which scarlet fever could have been produced by that milk, and the majority of cases of scarlet fever must have occurred before that day, as one cannot assume that in all these cases the period of incubation was protracted to such length as seven days. But mark what really did happen. Dr. Darbishire states that no case occurred till March 10, on which day two cases of sore throat and one case of scarlet fever occurred; on March 11, one case of sore throat; March 12, two of sore throat and one of scarlet fever; March 13, four of sore throat and two of scarlet fever; March 15, one of sore throat and one of scarlet fever; March 16, two of sore throat and one of diphtheria; March 17, one of sore throat; March 18, one of sore throat.

Now, all these cases were proved by Dr. Darbishire to have been caused by that milk. There occurred subsequently other cases, but these were traced to have been due to secondary infection from person to person.

This is a good illustration of a milk epidemic, in which the milk most probably did not receive the contagium by human agency. And there are other milk epidemics which on analysis of dates lead to the same conclusion. The infection of this milk was probably brought about, as I shall show you hereafter, in some other way.

As an instance of the third kind, viz., where milk has clearly not been infected from a human source, I will refer to Mr. Power's report in 1883 on an epidemic outbreak of scarlet fever in St. Giles and St. Pancras. "The disease was distributed with a milk service derived from a Surrey farm. In this case two facts could be affirmed; the one that a cow recently come into milk at this farm had been suffering from some ailment, seemingly from the time of her calving, of which loss of hair in patches was the most conspicuous manifestation; the other that there existed no discoverable means by which the milk, which had coincided with scarlatina in its distribution, could have received infective quality from the human subject." (Medical officer's report for 1885–86, pages v and vi.)

The medical department of the local government board have from these facts drawn the conclusion that "distrust must be placed on the universally accepted explanation that milk receives infective properties directly by human agencies," and further that "the question of risk from specific fouling of milk by particular cows, suffering, whether recognized or not, from specific disease, was seen to be arising." This view received striking confirmation and proof by a report of an outbreak of scarlet fever that occurred at the end of 1885, and the beginning of 1886, in the North of London, which was investigated by Mr. Power. His report is published *in extenso* in the report of the medical officer of the local government board for 1886. I will here give you the substance of it. Mr. Wynter Blyth, medical officer of health for Marylebone, "had last December observed a sudden outbreak of scarlatina in his district to be associated with the distribution of milk coming from a farm at Hendon, and had found reason for believing that the disease had prevailed exclusively among customers furnished with milk from that source." Mr. Power on a more extended inquiry found that a similar prevalence of scarlatina had occurred about the same time in other parishes in and near the metropolis that were furnished with milk from the same farm. By careful inquiry, Mr. Power could with certainty exclude any contamination of the milk from a human source, or that anything of the kind known as "sanitary" conditions could have had any concern with the infectivity of the milk. Mr. Power showed conclusively that only certain sections of the milk supplies of this farm, and finally only certain cows from which these sections of milk were derived, had any relation to the observed results. "In the end," says the medical officer, "he has demonstrated, beyond reasonable doubt, the dependence of the milk scarlatina of December on a diseased condition of certain milch cows at the farm—a condition first introduced there in the previous month by some animals newly arrived from Derbyshire; and he finds strong circumstantial evidence for believing that the later phenomena of this dependence were brought about through the extension of the diseased condition of one set of animals to another set, after the fashion of an infection."

Now this disease, as it presented itself in some of these Hendon cows, consisted in the presence of sores in different parts of the skin with loss of hair in patches, ulcerations on the udder and teats, and a visceral disease, notably of the lungs, liver, kidney, and spleen, which, although milder in character, very much resembled the visceral lesions occurring in cases of human scarlet fever. By experiment it was shown that the matter of the ulcers of the udder is possessed of infective power, inasmuch as on inoculation into the skin of calves the same ulcers are reproduced. Further, it was shown that in the ulcers of the cow there existed in large numbers a species of micrococcus, which, on being planted on artificial nutritive media, such as are used for the study of bacteria, produces in a few days a crop of micrococci, possessed of very distinct characters by which they are distinguishable from other bacteria.

When calves are inoculated from a cultivation of this micrococcus, they become, after an incubation period, affected with a cutaneous and visceral disease the same as the disease of the Hendon cows. From the blood of these animals the same microbe was recovered by cultivation.

To sum up, then, it has been shown that at this Hendon farm there existed certain cows affected with a communicable disease which, in many points of its pathology, bears a great resemblance to human scarlatina; further, that the milk of these cows gave scarlet fever to human beings; and lastly, that a particular microbe was obtained from these cows, which in calves produced a disease similar to the one from which those cows were suffering. In order to complete the evidence thus far obtained, it was necessary to prove that scarlet fever in man is due to the presence and multiplication in the blood and tissues of the same micrococcus, and that this microbe, if obtained from human scarlet fever, produces in the cow the same disease as is produced by the micrococcus of the Hendon cows. Now this proof has been satisfactorily given. In the first place, it has been shown that in the blood and tissues of persons affected with scarlet fever there occurs the same micrococcus as was present in the cow, both being identical in microscopical and in cultural characters. In the second place, it was found that the action of this microbe on animals is exactly the same as the micrococcus found in the Hendon cows. Calves and mice, after inoculation or feeding with a trace of the growth of both sets of micrococci, become affected with cutaneous and visceral disease similar to human scarlet fever. In calves, the disease is of the same mild type as in the Hendon cows. I have lately ascertained that milch cows inoculated with the human scarlet fever micrococcus developed readily a disease identical in every respect with the Hendon disease, inclusive of the ulcers on the teats and the sores and loss of hair in patches in different parts of the skin. Further, it was shown that from the blood and the tissues of these animals infected with one or the other set of cultivations, the same micrococcus was recovered. I will remind you that in all infectious diseases which have been proved definitely to be associated with a particular species of microbes, this microbe introduced into a susceptible body thrives and multiplies, and thus sets up the diseased condition, differing of course with the different species of microbes. I think I may after this say that this microbe, *Micrococcus scarlatinæ*, is the cause of human scarlet fever; further, that it produces in bovine animals a disease identical with the Hendon disease and human scarlet fever, and that consequently, while the cow is susceptible to infection with human scarlet fever, it can in its turn be the source of contagium for the human species, as was no doubt the case in that milk epidemic from the Hendon farm.

I shall now give a striking piece of evidence well in harmony with what I have mentioned hitherto. In October, 1886, Prof. Corfield forwarded to me certain tins of condensed milk, sold under the name of "Rose brand." This milk was under suspicion of having produced scarlet fever in a number of persons that had partaken of it. From one out of three tins of this condensed milk, I have obtained by cultivation a microbe which in every respect, morphologically and in cultures, is the same as the microbe obtained from the Hendon cows and from human scarlet fever. The action of the microbe of the condensed milk was also tested on animals, calves, and mice, and it was found that it produced the identical disease that was produced by the microbe of human scarlet fever and of the Hendon cows. I may add that this Rose brand of condensed milk is, like all condensed milk, obtained from cows' milk. The Rose brand is a cheap article, and meant for the poorer classes. Probably it has not been sufficiently heated in the tins before sealing the latter. That this is so can be inferred from the fact that every tin of this brand which I opened contained some organisms. Thus, for instance, I find that one tin contained the scarlet fever microbe and another species of micrococ-

* Lecture delivered by Dr. E. Klein, F.R.S., at the Royal Institution, on Friday, May 27, 1887.

cus. Another tin contained a harmless species of micrococcus only; and a third tin opened contained a micrococcus and a species of bacillus.

Another piece of interesting evidence concerning the *Micrococcus scarlatinæ* is this: There occurred during the beginning of last year a severe epidemic of scarlet fever in Wimbledon. This epidemic was also traced to milk coming from a particular farm. In one of the houses supplied with this milk there occurred cases of scarlet fever among human beings, and at the same time a pet monkey, who also consumed a good deal of the milk, became ill It died after five days. I had the opportunity to make a *post-mortem* examination of this animal, and there could be no doubt about its having died of scarlet fever. From the blood of this monkey I obtained by cultivation the same micrococcus as was obtained from human scarlet fever, from the Hendon cows, and from the condensed milk. Experiments made on animals with this micrococcus of the Wimbledon monkey showed that the same disease is produced both by inoculation and by feeding.

It having been proved, then, that the cow is susceptible to infection with scarlet fever from man, the next important question is this, How does the milk of such infected cows assume infective power? Clearly in one of two ways: first, either the milk becomes infected by the milker during the process of milking, particles of contagium being rubbed off the ulcers of the udder or teat; or, the milk *per se* is possessed of infective power—that is, it being a secretion of a constitutionally diseased animal. From previous and from more recent observations, I am inclined to think that both views hold good.

I now come to the question, How is the spread of scarlet fever by milk to be controlled and checked? This question resolves itself into three parts. First, prevention of infection of the cow by man, directly or indirectly; second, prevention of infection of the cow by the cow; and third, destruction of the contagium of the milk of such cows.

As regards the first, all those rules which have been laid down to prevent infection of one human being from another, of milk or any dairy utensil by contact or otherwise with a person suffering from scarlet fever or coming from an infected house, apply also here; and this part of the subject comes under the general aspect of the proper sanitary management of dairies, which is acted upon in all well-managed dairies.

As regards the second, viz., prevention of infection of the cow from the cow, this is obviously more important and more difficult to be carried out. I say obviously, because one cow affected with the disease is capable of communicating it to others in the same farm, and when moved to another farm also to the cows there.

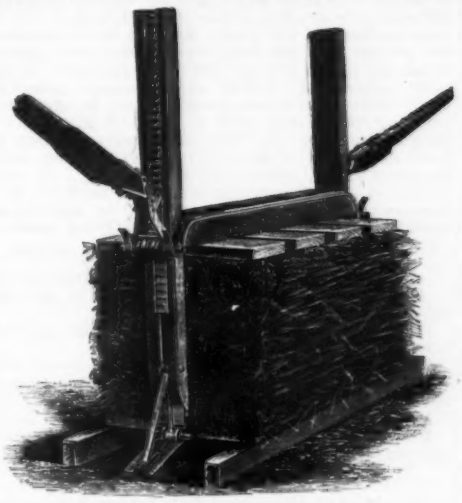
The disease in the cow being of a mild character, is easily overlooked. The disease in the skin of the cow may be present and slight, or may be absent in its more conspicuous manifestation, whereas the visceral disease is of so mild a character that it requires an expert to diagnose it. When a cow shows the disease of the skin and on the udder well pronounced, such an animal will have to be carefully examined for visceral disease. I need hardly say that among the many cutaneous disorders of the cow, known and unknown, there may be one or the other which bears a resemblance to the cutaneous disorder occurring in scarlatina. Such cutaneous disease must be carefully excluded before an animal is condemned. But, if visceral disease should be diagnosed as well, the animal should be carefully isolated and its milk should not be used. And it must be clear from this that every dairy should be permanently under the supervision of an expert, and in this the veterinary profession should be as eager for the work as the medical sanitary officers are and for some time past have been. But, judging from the attitude assumed by the veterinary authorities, I am afraid the veterinary profession has not yet grasped the full responsibility that rests on them, both toward the general public and the dairy farmers. Instances are on record when, on the milk from a particular farm having been proved or even suspected to bear any relation to a scarlet fever epidemic, the business of such farm became temporarily or even permanently suspended, and the pecuniary loss of the owner of such farm irrevocable. That the disease in the cow which I have described to you as scarlet fever is as yet unknown to the veterinary profession does not do away with the existence of such disease, and I venture to say that the fact of its being as yet unknown to and unrecognized by them should stimulate them to try to recognize it.

Now the third question, as to the destruction of the contagium in the milk. This, I am glad to say, is very easily carried out. Heating milk up to 85° C. or 185° F., that is considerably under the boiling point, is perfectly sufficient to completely destroy the vitality of the microbe of scarlet fever. In harmony with these experiments on the influence of heat on the microbe of scarlet fever, I can quote, besides the observation given above by Dr. Robertson, also the following observations recorded by Dr. Jacob, Medical Officer of Health of High Ashurst and Headley, and reported in 1878, to this effect. Between June 1 and 7, there were fifteen cases of scarlet fever in three distant houses, the inmates of which had had no communication with infected persons, but had all been supplied with milk from a farm where a certain cow man worked. This cow man had in his family several children ill with scarlet fever. The cow man continued milking the cows during the illness of his children, though he did not himself have the fever, and the milk was not taken into his cottage; but the point which I wish to bring out is this, that other houses besides those in which scarlet fever had broken out had been supplied with the same milk, but no scarlet fever occurred in them, and why? because all these had consumed only the scalded milk.

I should therefore strongly urge that all milk should be boiled, or at any rate heated to at least 85° C. (that is 185° F.), before being consumed. Judging by the large number of cases of scarlet fever recorded in these milk epidemics, one is justified in saying that a considerable percentage of the total number of cases of scarlet fever would have been avoided thereby. Not all, because unfortunately the rules of isolation of patients suffering from scarlet fever are not always rigorously carried out, and therefore infection from person to person will occur. Nor would prevention of scarlatina by milk exclude scarlatina by cream. Cream cannot be easily subjected to heat; and in the epidemic of scarlet fever that occurred in South Kensington in 1875, and that was investigated by Dr. Buchanan, cream was the vehicle of the contagium. But considering the prominent position that milk occupies in every household with children, the possibility of infection with scarlet fever by raw milk deserves careful attention.

IMPROVED HAY PRESS.

AT the recent Royal Agricultural Show, Smithfield, W. J. & C. T. Burgess exhibited a new press for hay, whose simplicity of action and general handiness apparently created much interest in the new appliance. The illustration shows the press ready for action, the toggled levers, racks, and all the mechanical arrangements being so simple that a boy can work it. For places where loose stuff needs pressing, a box could be introduced instead of open sides. The usefulness of



IMPROVED HAY PRESS.

the appliance is so readily apparent that there is no necessity to dilate upon it. The press is easily taken to pieces, and its removal from place to place is a very easy matter.

ASBESTOS THEATER CURTAIN.

THE accompanying engraving shows the abestos curtain at Terry's Theater, Strand, London, and one designed for the Queen's Theater, Manchester. This curtain is made of asbestos cloth on an iron frame. The advantages of this form of curtain, designed and registered by Mr. Lawrence Booth, are its cheapness, lightness, strength, and ease of manipulation, and it has received the highest commendation of the city justices of Manchester, and their professional adviser, the city surveyor. A special method of preventing the iron frame from "bulging" or altering its shape in case of fire or sudden variations of temperature is employed. By using weights not quite sufficient to counterpoise the curtain, the work of raising and lowering is very light.

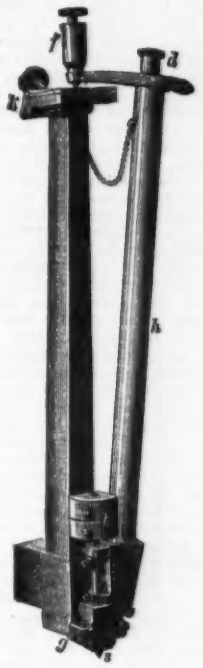
Combustible ropes may be employed, which on being released by the action of fire or otherwise, will allow the curtain to descend of itself. The pockets are provided to catch the counterbalance weight in case of the breakage of the chain, so as to prevent personal injury. The friction rollers are put on the balance weights to insure their free action. Friction rollers are also fitted on the curtain frame to give freedom of action in raising and lowering. The hinging of the lower part of the frame, so as to admit of its being raised to the top of the proscenium opening when there is not sufficient room for a curtain of the ordinary make to be raised above the proscenium opening, is a valuable addition. The asbestos cloth is specially strengthened by a fine wire running through each abestos strand, and is stretched across the whole of the framework, and fastened thereto by means of hoop iron and bolts. A double thickness of asbestos cloth may be used, one thickness on each side of the framework, with an air space between.—*The Engineer.*

WRITING APPARATUS FOR ENGRAVING SMALL FIGURES.

By A. REPSOLD and SOHNE.

WE have used for about ten years the writing apparatus here described for making figures on our instruments, for which it has proved to be well adapted.

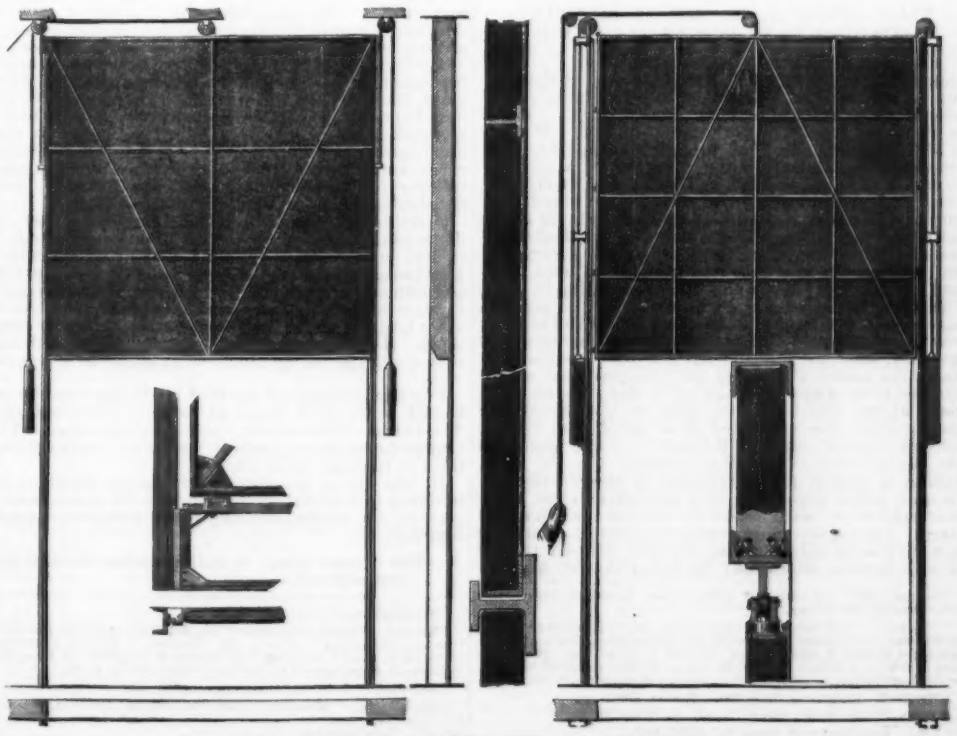
It consists in general of a lever, *h*, which rotates



upon a double joint, *g*, whose longer arm is provided with a guiding point, *f*, which is moved by hand in engraved figures. The shorter arm then repeats the figures on a reduced scale by means of a writing needle with a single point, *s*, which works up and down in the line of the lever, and is pressed down by a weight, *i*. The double joint is fastened to the fixed part of the apparatus, which, according to the circumstances, is clamped either in a horizontal or vertical position. The simple arrangements for retaining the copying plate, *k*, are carried on a strong arm. If the lever works in an upright position, the weights act directly upon the writing needle. If the lever works horizontally, pressure is brought upon the needle by a small bent lever. When no writing is being executed a spring in the lever holds up the writing point. When writing is to be done, the tracing point, *f*, pressed down by a spring, is placed on the tablet, *k*. By pressure on the head, *d*, of the lever the writing point is depressed upon the surface to be inscribed, and the tracing point is moved through the lines of the engraved characters.

If numerals of several figures are to be written, the necessary figures for tracing from are firmly fastened next to one another on the tablet.

With some care, by means of this apparatus, figures only 0·3 mm. ($\frac{1}{75}$ inch) high can be written.—*Zeitschrift fur Instrumentenkunde.*



ASBESTOS THEATER CURTAIN.

THE DEVELOPMENT OF THE MERCURIAL AIR PUMP.*

By Professor SILVANUS P. THOMPSON, D.Sc., B.A.

WITHIN the range of the physical sciences there are many subjects of interest to the investigator, some of them of importance in the technical industries, which yet are little known, save to the close student of scientific literature. An idea occurs to some original worker, who makes experiments, records results, draws inferences, and embodies his investigations in a memoir or note in the more or less obscure journal of proceedings of some scientific society, where it remains buried amid a heterogeneous mass of like matter. A few years later another worker, not knowing what has been done, stumbles across a similar idea, constructs his apparatus, makes his experiments and observations, and in turn consigns his work to a similar temporary oblivion. Years after, or it may be centuries, the progress of science in other departments reaches a point where it touches the unremembered work of those who are gone. Were that work available, were even a plain clew to its existence known, it would be at once brought into line and made useful. For want of such a clew it remains buried, and the world has to wait for some other to reinvestigate what already was a portion of acquired knowledge, and the useful application to industrial purposes is delayed—perhaps for years. He who will explore the dusty corners of science, will hunt up the hidden treasures, arrange them, co-ordinate them with more recent knowledge, and render access to them easy for the busy workers around him, performs a service which, though it brings no renown, is at least useful † In such dusty corners of science lie the scattered fragments of the literature of the mercurial air pump.

All true mercurial air pumps are, of course, based upon the principle of the barometer. That is to say, in all of them the vacuum is constituted in the manner invented by Torricelli, namely, in an inclosed space above a barometric column. In all of them the object is to render the Torricellian vacuum as perfect as possible. In some of them the object is effected by driving the air upward out of the barometer head by raising the barometric column. In others the air is forced downward by the injection of more mercury into the barometer head. In others, again, the air is pushed up one barometric column and down another. In some recent kinds of mercurial pump, several of these forms are combined. Other pumps again depend on the injection of mercury at high pressure through an orifice. These distinctions will furnish us with a basis for classification. Before attempting this, however, a few general historical notes may be given.

In 1643, Torricelli discovered the possibility of producing a vacuum above the top of a mercury column, by filling with mercury a tube closed at one end and then inverting it into a cup containing mercury. Until 1650—a period of seven years—when the mechanical air pump was invented by Von Guericke, there was no other way of producing a vacuum, and the Florentine academicians, who made in the interval many experiments on the properties of vacuous space, employed as their pump a Torricellian tube (Fig. 1) enlarged at its

FIG. 1.—TUBE USED BY FLORENTINE ACADEMICIANS FOR EXHAUSTING.

upper part into a bulb or reservoir, closed at the summit by a cover, luted on with some suitable sort of cement. The apparatus is figured in Daguin's "Traité de Physique," vol. i., p. 278 (edition of 1855). Writing in 1855, Daguin states that though the employment of the vacuum obtained by the lowering of a mercury column had been perfected by Baader and by Hindenburg, their machines required such a large quantity of mercury that they had been abandoned in favor of the mechanical air pump. The Torricellian method of exhaustion was pursued, however, whenever a very perfect vacuum was required, for example by Count Rumford ‡ in his researches upon the propagation of heat. The bulb to be exhausted he sealed to the top of a barometric tube having a constriction near the top. It was then filled with hot recently boiled mercury and inverted, when the mercury left the bulb vacuous. It was then sealed off before the blowpipe just as exhausted glow lamps are sealed off to day. An arrangement almost identical with that of the Florentine academicians was suggested as a novelty so late as 1810 by Traill.§ In 1845, Edward A. King‖ patented the construction of an incandescent electric lamp, having a carbon pencil situated in the Torricellian vacuum at the upper end of a barometer tube, a further suggestion being made for sealing the exhausted lamp. Among still more recent methods of producing in a glow lamp a Torricellian vacuum without the aid of any specific pump may be noted that of Andre,¶ who seals the lamp globe to the top of a barometric tube, another short tube opening into the bulb being sealed on above. Mercury is driven from below until it fills the lamp, when the upper tube is temporarily stopped, the mercury being then lowered, creating a vacuum into which the occluded gases are liberated. The mercury is then raised, and these gases expelled through the stopper, and the lamp is sealed at the top. Then the mercury is lowered and the lamp is sealed off at the bottom. Swinburne* has also tried this method, but has not found it successful. None of these processes of utilizing the Torricellian vacuum amounts to the invention of a distinct Torricellian air pump. Although most of the mercurial air pumps to be described started from the fundamental notion of producing a barometric vacuum, it seems possible, if not probable, that some, at least, of the various forms had a different origin. Two of the main defects of the ordinary mechanical air pump are the faulty packing of the pistons and the unavoidable clearance space between the piston and the end of its cylinder. It naturally occurred to several experimenters, possibly to many, that both these defects might be obviated by covering the piston with a layer of mercury. Air pumps thus provided with a mercury packing have been described by Kravogl † for exhausting, and by Regnault ‡ and Cailletet for compressing. In the following sketch, however, attention is confined to the barometric species of pump. It will be convenient to classify these machines under the following heads:

CLASSIFICATION OF MERCURIAL AIR PUMPS.

I. Those which drive the air up a barometric tube.
II. Those which drive the air down a barometric tube.
III. Those which drive the air up one barometric tube and down another.
IV. Combination pumps.
V. Injection pumps, dependent in their action upon the velocity of efflux of a stream of mercury.
VI. Mechanical mercurial pumps.

Under the first three of these classes there are subclasses, comprising "shortened" pumps.

CLASS I.—UPWARD DRIVING PUMPS.

The oldest of all mercurial air pumps belongs to the class in which the air is forced upward above the top of a barometric column. It was invented by Emanuel Swedenborg, the famous theosophist, and is described in his "Miscellanea,"§ published in 1722. The apparatus and a drawing of the machine is given, which is reproduced in Fig. 2. A glass receiver, B, stands upon a

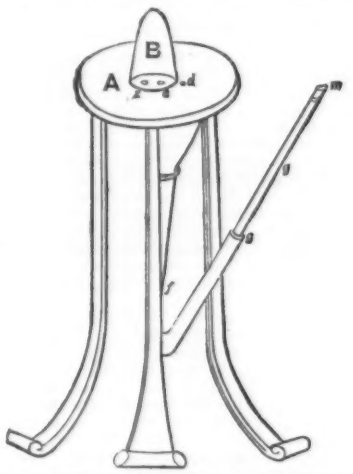


FIG. 2.—SWEDENBORG'S MERCURIAL AIR PUMP.‖

plate, A, as in the ordinary mechanical air pump, and the plate, A, is supported on three legs forming a tripod table. "Beneath this table," to follow Swedenborg's own words, "there is a certain conical vessel, E, of iron, hollow, and accurately fixed on the under side of the table, so that it includes two apertures, *c* and *d*, furnished with valves." The valve, *c*, opens downward, the valve, *d*, upward. The lower end of the iron vessel ends in a flexible leather tube, *ff*, to which is adapted a piece of iron tube, *gg*, ending in an open mouthpiece, *m*. This iron tube was to be alternately raised and lowered precisely as is done in the modern Geissler or Toepler pump with the mercury vessel. Swedenborg's instructions are precise.

"OPERATIO.—Immitte mercurium vivum per (*m*), illa copia, ut repleat (*f*) (*f*) et aliqualem partem, E; si dein sursum levas (*g*), tunc mercurius ascendit in E usque ad mensulam: si dein demittis idem (*g*) infra altitudinem 28 pollicum, tunc descendit mercurius in E, attrahit secum aërem ex recipiente per valvulam (*d*), et sic levando et demittendo, dum omnis aër sit exantlatus. Habeas etiam foramen quoddam in (*z*) sub mensula, quod aperias ope trochleæ, et immittas aërem cum velis."

Further instructions say that the lifting must be continued until some drops of mercury come out at *d*. The nature of the valves, *c* and *d*, is not stated. They appear to have been such as were used in the current form of mechanical air pump.

In the above description and figure, Swedenborg's lettering is adhered to, but it may be convenient to state that in all the following cuts the lettering adopted is as follows:

A.—The "pump head" or hollow globe, which is filled and emptied.
B.—The barometric column or tube, also called the "shaft" of the pump.
b.—Barometric gauge.
D.—Drying apparatus.
E.—Eject tube or valve.
F.—"Fall tube."
G.—Gauge.
g.—The flexible lifting tube connecting S and B.
H.—Overhead tube.
J.—Mercury valve.
K.—Collecting chamber.
L.—Pressure chamber at bottom of shaft.
M.—Second chamber for partial vacuum.
N.—"Side tube."
P.—Piston.
p.—Plug of rubber.
R.—"Receiver."
r.—Regulating pinch cock.
S.—"Supply vessel," or reservoir of mercury.
s.—Rubber packing.
T.—Tap.
t.—Air trap.
U.—The valve opening inward from the exhaust tube to the lower end of the pump head.
V.—The valve opening outward at the upper end of the pump head.
W.—Winch.
Y.—Three-way communication to atmosphere, or auxiliary pump.
Z.—Return tube for mercury.

Sixty years elapsed before a second form of mercurial pump was devised, by Dr. Joseph Baader,* who, about 1784, devised the pump depicted in Fig. 3. This pump

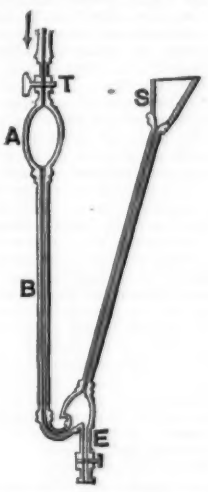


FIG. 3.—BAADER'S PUMP. (FIRST FORM.)

consisted of a hollow ellipsoidal vessel, A, at the summit of the barometric column, B, terminating above in a passage containing a three-way tap below it, bent round into a chamber with an outlet tap, and having a second rigid tube, inclined at an angle, ending above in a funnel-shaped vessel to receive the mercury. To work this pump, the bottom tap was closed, and the three-way tap was turned so as to make the pump head, A, communicate with the outer air. Mercury was then poured into S until A was filled. The three-way tap was then turned to cut off communication with the air, and to connect A with the receiver or other vessel to be exhausted. The bottom tap was then opened, and a portion of the mercury permitted to run out until the top of the barometric column was below A, producing a partial vacuum in the pump head and the receiver. The lower tap was then closed, the three-way tap returned to its former position, and the mercury which had flowed out of the pump was poured again into S, and the operation repeated. It will be obvious that this operation is equivalent to raising and lowering the supply vessel, as in the pumps of Geissler and Toepler, and their prototype of Swedenborg. Baader had a curious history. In 1784, when this pump was devised, he was studying in Vien-

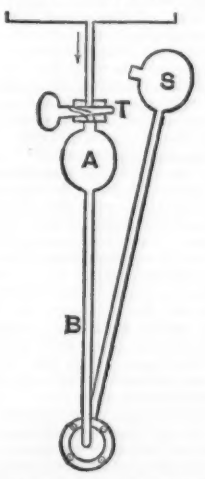


FIG. 4.—BAADER'S PUMP. (SECOND FORM.)

na. He afterward went to Göttingen, thence to Edinburgh, where he took the degree of doctor of medicine, but he quitted the medical profession for that of mining, and was afterward connected with an iron works at Wigan. Gehler states that Baader abandoned

* Lecture before the Society of Arts, London, November, 1887. From the *Journal* of the Society.

† The author here desires to express his indebtedness to the many friends who have assisted in collecting this information, also to the valuable paper by Herr E. Bessel-Hagen, referred to in the text. He also desires to refer to a memoir by Prof. Hellmann, of Rigi, a copy of which he received only after the greater part of this paper was already compiled.

‡ Rumford. Essays, vol. ii., p. 393. (Edition 1798.)

§ Traill. "Nicholson's Journal," xxi., pp. 63 and 161.

‖ King. Specification of Patent No. 10,919, 1845.

¶ Andre. Specification of Patent No. 4,654, 1861. Electric Illumination, vol. i., p. 005.

* See *Electrician*, xix., 159, July, 1887.

† Kravogl. "Carl's Repetorium," iii., 362, 1868. See also Deschanel's "Natural Philosophy" (1881), i., 190. Similarly a mercury packing was employed in a water pump by Haskins, and is described in Desaguller's "Course of Experimental Philosophy" (1763), vol. ii., p. 491.

‡ Regnault. "Relation des Experiences," ii., 553.

§ Swedenborg. "Miscellanea observata circa res naturales, ei praesertim circa mineralia, ignem, et montium strata." Lipsiæ, 1722, p. 101. See also "Gren's Journal," vol. iv., p. 407.

‖ Swedenborg. "Miscellanea observata circa res naturales." Lipsiæ, 1722. Fig. 11.

* Baader, See Hubner's "Physikalisches Taschenbuch." Saisberg, 1784, p. 630, referred to in Gehler's "Physikalisches Worterbuch," vi., p. 902 (Ed. 1831).

his first form of pump in favor of a second,* shown in Fig. 4, which differs from Fig. 3 in having the supply vessel capable of being raised and lowered, not by a flexible tube, but by turning it about on a joint provided at the meeting point of the barometric tube and the supply tube.

A very finely constructed pump on Baader's principle exists in the collection of apparatus in the physical laboratory of University College, London, having apparently been acquired in April, 1828. There is no maker's name or date on the apparatus, but it belongs to and is catalogued as being "the Torricellian part" of a fine double barreled air pump (price £100) by the famous instrument maker John Cuthbertson, of Amsterdam and London. It is shown in Fig. 5. The

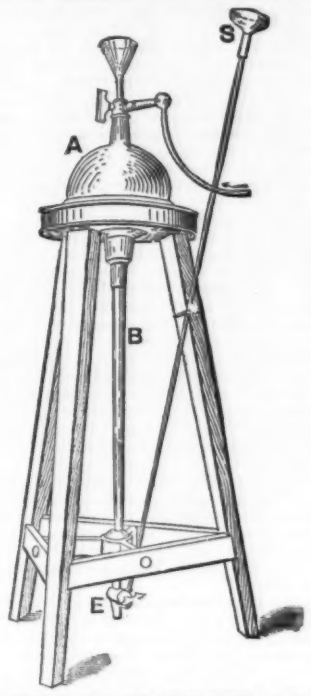


FIG. 5.—PUMP IN UNIVERSITY COLLEGE.

exhaust pipe of brass leads from the three-way tap at the top to a union joint below the plate of the mechanical pump, so that the exhaustion having been carried in the ordinary way to a certain point, it should be completed by using the Torricellian part. The apparatus is mounted on a massive tripod of mahogany; the fittings of the taps are of metal (steel or iron); the height from floor to the top of the exit funnel is just under two meters; the height from the bottom tap to the bottom of the pump head is just over one meter. The barometric tube, B, is of glass, as is also the supply tube. The pump head is a substantial glass vessel, almost exactly one meter in external circumference. Hence it would require about 400 lb. of mercury to work the pump. Prof. Carey-Foster states that it is believed to have been acquired by Dr. Lardner's direction. He has no knowledge of its having been used. I have not been able to discover in any of Cuthbertson's pamphlets or price catalogues now extant any reference to this part of the apparatus.

A pump on the same principle was patented in 1881 by Mr. Rankin Kennedy. It is described later.

In 1787, C. F. Hindenburg† described the pump shown in Fig. 6, closely resembling Baader's, but having a piston and cylinder for the purpose of driving the mercury up and down in the barometric tube.

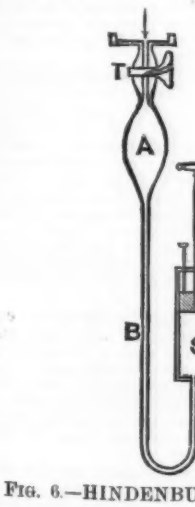


FIG. 6.—HINDENBURG'S PUMP.

Cazalet,‡ of Bordeaux, states, in 1798, that he has constructed an apparatus like Hindenburg's, of glass and iron, and that he has succeeded with it in getting an exhaustion of one millionth of an atmosphere. How he measured this does not appear. A similar kind of pump appears to have been used by Michel.*

In 1804, A. N. Edelcrantz† published a "Description of a mercurial air pump of unlimited exhausting power, with a wooden piston." This pump (Fig. 7), which appears to have been independently conceived, is on the same lines as Hindenburg's, but with superior mechanical arrangements. The three-way tap, instead of being bored diagonally toward the handle, is bored toward the outer end, as in the modern Geissler pumps, and the wooden piston (P) is moved in its stout wooden casing by a rack and pinion motion.

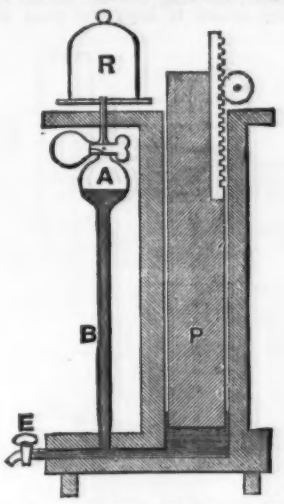


FIG. 7.—EDELCRANTZ'S PUMP.

Some years after this "Nicholson's Journal" contains a description of Traill's‡ apparatus, which has already been mentioned. It drew a further communication from R. Bancks, instrument maker in the Strand, that he had constructed similar apparatus for Mr. Children at a prior date.

In 1824, Joseph H. Patten§ wrote an "Account of a new air pump," which, like those of Hindenburg and Edelcrantz, had a piston to raise and lower the mercury, but which in another point more nearly resembled the original pump of Swedenborg. The pump head consisted of a wide mouthed glass globe, on the top of which was fixed a flat metal plate with a raised rim. In the center of this was adopted a metal pipe, having a valve opening downward below it. This valve, a mere metal plug, was held upon a stiff wire which entered the tube above, and was continued downward to the summit of the barometric tube, where it ended in a ball float. When the mercury rose it lifted the ball and closed the valve, and maintained it closed till it once more fell. The air in the pump head was expelled through a separate valve opening outward in another part of the plate.

Patten suggested that, instead of the stiff wire, ball, and valve, the exhaust tube should be prolonged downward to near the bottom of the globe. The publication of this description drew from Professor J. F. Dana‖ some remarks suggesting, apparently without knowledge of prior inventors, that it would be preferable to use a three-way tap. To this Patten replied in a later issue in a strongly personal vein.

A more complex form of pump, in which the mercury was moved by air pressure, applied by pouring mercury into a second vessel containing air—somewhat on the plan of Hero's fountain—was described in 1824 by Dr. E. Romershausen,¶ and in 1825 by Uthe.** In each case a complicated six-way tap was requisite.

In the same year a pump by Oechsle†† was described, having a three-way tap connecting the pump head alternately with the air and with the receiver to be exhausted, and provided also with a barometer gauge beneath the receiver. The mercury was lowered and raised, as in Edelcrantz's pump, by a large wooden piston, but worked by a chain and winch.

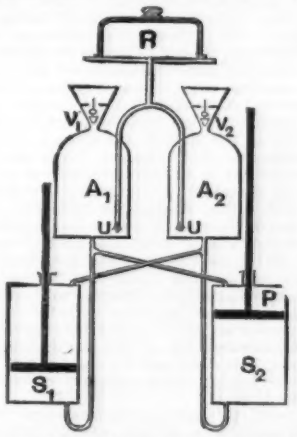


FIG. 8.—KEMP'S DOUBLE-ACTING PUMP.

Next in strict historical order is the very remarkable pump of Mile, 1822, which, however, belongs to the third class of machines.

K. T. Kemp,* of Edinburgh, in 1830, designed a remarkable double-acting pump. In this machine a winch, manipulated like that of the ordinary mechanical air pump, moves two pistons up and down in two cylinders (Fig. 8). These are full of mercury, which is thereby driven alternately into the two exhausting chambers, and which serve as pump heads. They are provided with valves to admit air from the receiver, and also with valves opening outwardly to let out the expelled air. The latter pair of valves are ingeniously provided with floats, so that they close while there is still some mercury remaining above the actual valve to seal the joint and make it air tight. The double pump of Gardiner described below (Fig. 17) closely resembles that of Kemp.

The year 1855 brings us to the famous pump of the late Dr. H. Geissler, of Bonn, which in his hands did such excellent work for exhausting the Geissler vacuum tubes. The first public mention of this pump appears to be in a pamphlet entitled "Ueber das geschichte elektrische licht," published in Berlin in 1858 by Dr. W. H. Theo. Mayer. The form at first given to this apparatus is shown in Fig. 9; which shows the vessel

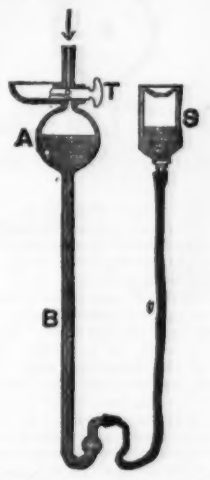


FIG. 9.—GEISSLER'S PUMP. (FIRST FORM.)

containing the supply of mercury, S, connected to the lower end of the barometric column, B, by a flexible India rubber tube, *g*. The pump head, A, is provided at the top with a large three-way tap, T. The operation of this simple contrivance is obvious. The air in the pump head is repelled by raising the supply vessel, while the tap is in such a position that the pump head communicates with the outer air. The tap is then turned so that the communication with the outer air is cut off, and communication is established with the vessel to be exhausted. This being done, the supply vessel is lowered down, when the mercury in the pump head sinks, and draws in air through the exhaust tube. The tap is then turned again, and the supply vessel is again raised to expel the air that has been drawn in, then the tap is turned and the supply vessel again lowered.

By repeating these operations a sufficient number of times, the air remaining in the apparatus is reduced to a very small portion of its original amount, and the column of mercury in the tube, B, stands up to very nearly the height of the barometer. The perfection of the vacuum is limited by two causes: the inherent imperfection in the three-way tap and the impossibility of expelling the film of air which adheres to the inner surface of the pump head. However perfectly the tap may be ground into its seat, however carefully it is lubricated with stiff grease, still air films will remain between the working surfaces.

There is a tendency for a channel to be formed in the film of grease at that part of the conical periphery of the tap where the apertures into it slide round against the internal wall of the glass seat; and through this channel in the glass minute bubbles of air force their way. Moreover, the grease itself may give off vapors which spoil the perfection of the vacuum. The Geissler pump is, moreover, subject to other defects, among which may be enumerated the heavy labor of raising and lowering the supply vessel, the liability to accident to the glass top, the liability to fracture of the pump head. The latter accident occurs not unfrequently, if, after a certain degree of exhaustion has been attained, the supply vessel is suddenly raised, for then, there being little or no air in the pump head to serve as a cushion, the mercury rising in the pump head strikes with a sudden blow against the upper portion of the pump head and fractures it. The long barometric tube or shaft of the pump is also liable to fracture. The working of the tap, being done by hand, requires continuous attention. Lastly, the process of exhaustion is slow.

The subsequent improvements relate to the removal of one or other of these drawbacks. Some of them were introduced by Dr. Geissler himself, and by his successor, Herr F. Muller, of Bonn. The form depicted in Fig. 9 (taken from Toepler's paper in "Dingler's Polytechnisches Journal," clxiii., p. 426, 1862) shows the kind of three-way tap (a modification of Senguerd's) originally used, in which the passage for the expulsion of the air was carried through the conical body of the tap to its end.

In another form, the same kind of tap was used, but the exhaustion was made through this longitudinal passage, the external tubular seat being prolonged and connected with the vessel to be exhausted. In this case the air was expelled upward through the transverse passage through the tap. In yet a third form the exhaust tube was sealed on at right angles to the external barrel, and the tap was pierced (on Babinet's plan) with a three-way transverse passage. In the

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* Baader. See Hubner's "Taschenbuch," cited above, referred to, with figure, in Gren's "Journal der Physik," ii., p. 326. See also Hindenburg, "De Antlia Baaderiana," 4to, Leipzig, 1787, referred to in Young's "Lectures on Natural Philosophy." A quarto volume published at Bayreuth, in 1797, under the title "Theorie der Pumpen," is possibly by the same Baader.

† Hindenburg. See Gehler's "Physikalishes Worterbuch," vi., p. 603 (1831 edition), which refers to Hindenburg, "Antliæ novæ hydraulico-pneumaticæ mechanismus et descriptio," Leipzig. 4to. 1787. Young mentions also Hindenburg, "De Antlia Baaderiana." Leipzig. 4to. 1791; and to Hindenburg, "De Antlia Nova," Leipzig. 4to. 1789.

‡ Cazalet. "Gren's Journal," i., p. 478.

* Michel. See "Gren's Journal," ii., p. 129.

† Edelcrantz. "Nicholson's Journal," vii., p. 188.

‡ Traill. "Nicholson's Journal," xxi., pp. 63 and 161.

§ Patten. "Silliman's Journal," viii., p. 144, 1824, and ix., p. 92, 1825. An almost identical apparatus, called an "oil air pump," by Sadler, is described by Gehler, vi., p. 606.

‖ Dana. "Silliman's Journal," viii., p. 275.

¶ Romershausen. "Neue hydrostatische luft-pumpe." "Kastner's Archiv fur Naturlehre," ii., p. 359, 1824.

** Uthe. "Dingler's Polytechnisches Journal," xvii., p. 272, July, 1825.

†† Oechsle . see Wucherer: Beschreibung einer grossen Quecksilbernen Luftpumpe, welche sich in dem physikalischem Cabinet in Karlsruhe befindet, "Kastner's Archiv," v., p. 329, 1825.

* Kemp. Description of a new Toricellian air pump. "Edinburgh Journal of Natural and Geographical Science," ii., p. 95, 1830. See also in Fechner's "Repertorium des Experimentalphysik," i., p. 116; and Taf. 3, Fig. 13, 14, 1832. Also "Baumg. und Ett. Zeitschr., viii., 193.

most recent form given to the Geissler pump by its makers, there are three taps, one of them, a large one, being a three-way tap of the last mentioned kind, simplified by having only one transverse bore of conical form. The arrangements of this pump are shown in Fig. 10, in which T· is the three-way tap, and T_2 and T_3 plain taps of a smaller size.

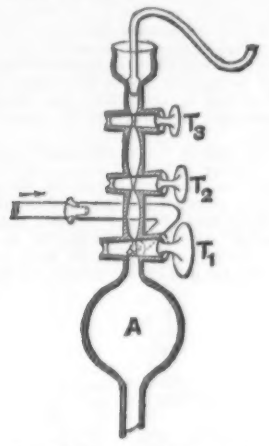


FIG. 10.—GEISSLER'S PUMP. (RECENT FORM.)

The use of the two upper taps is to enable the last traces of air to be more perfectly expelled from the pump head. During the ordinary working of the pump the two top taps are always left open. After the exhaustion has reached a sufficient point, the large tap is turned so as to cut off communication with the exhaust tube, and to open communication from the pump head upward through all the taps. The supply vessel is then raised so high as to drive the mercury up above the level of the topmost tap. The top tap is then closed, and, by sinking the supply vessel, the mercury is caused to fall below the pump head. It is then slowly raised, driving before it all the air that may remain in the pump head, and collecting it just below the top tap. As soon as the mercury has risen through the second tap, this is then closed, and the mercury once more lowered. It will be seen that if the space between T_2 and T_3 is sufficiently great, this residual air will not become compressed to anything like atmospheric pressure, and hence the air films forming in the upper part of the pump head or in the channels of the three-way tap will be comparatively slight. The curved tube at the top is used for collection the gases extracted in chemical operations. The horizontal exhaust tube is usually connected with drying vessels, and with appropriate gauges. The complete pump as used for the purposes of the chemical laboratory is shown in Fig. 11.

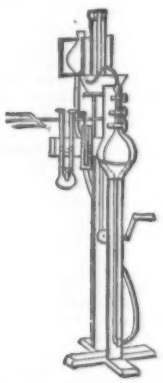


FIG. 11.—GEISSLER'S PUMP. (COMPLETE.)

Morren's pump* is practically identical with Geissler's save in a detail concerning the three-way tap, which has, instead of having a glass cone with a longitudinal passage pierced through it, a steel cone, with a channel or groove cut in the side. Another almost identical form was described by G. Jolly,† about the same time. It resembled Geissler's first form, but was provided with a mechanical device of a winch and pulley, to raise and lower the supply vessel. This device was speedily adopted by other makers. It may be seen in the latest form of Geissler's pumps. Jolly's pump also has a steel three-way tap. Von Babo‡ sought to replace the egg-shaped pump head by a glass cylinder, strongly held together between circular steel ends, and having two automatic valves opening into and out of it precisely as in Kemp's pump of 1839 (Fig. 8). Poggendorff§ further improved the mechanical lift by adding a counterpoise weight

Alvergniat‖ introduced an automatic valve into the exhaust tube, to prevent the mercury from being driven back into the exhausted vessel. Weinhold¶ modified the glass three-way tap, and added above it a small chamber, above which the opening into the outer air was closed by a second glass tap of simple construction. The use of this upper chamber to secure a more perfect vacuum brings this form almost into identity with Geissler's later form. The device of interposing such a chamber between the three-way tap and the external air was independently suggested in 1875 by Kundt and Warburg,* and appears to have been already adopted by Geissler† in 1873.

In the years 1873 and 1874, Dr. Joule‡ devised several forms of mercurial pump, having but one valve, an India rubber plug, V, fitting into a cone seat at the top of the pump head, allowing the air to be expelled. A little mercury above it kept the joint secure. The

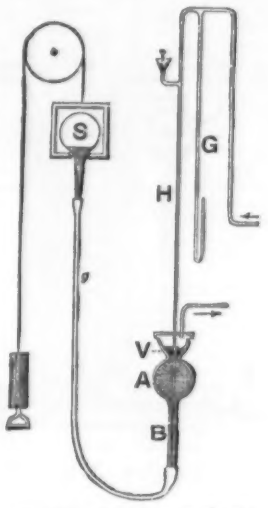


FIG. 12.—JOULE'S PUMP.

necessity of emptying a second valve was obviated by the device (previously used by Mile) of connecting the vessel to be exhausted to the pump by means of an overhead tube, H, of more than barometric height, which passed into the pump head, its open lower end descending nearly to the bottom of the chamber. This acted automatically as a trap; for, on the raising of the supply vessel, the mercury rising in the pump head first closed the orifice of the head tube, so cutting off communication with the air that remained in the pump head, but never rising in that tube to a height greater than 76 centimeters above the level of the valve. Another feature of Joule's pump was that the supply vessel was closed at the top, being made of a globular flask. By allowing only a certain amount of air to enter this flask, the pressure inside was kept at less than atmospheric, enabling the length of the shaft, B, to be reduced. Later, a conical ground glass tube was used in place of the India rubber plug for a valve.

(To be continued.)

* Morren, "Annales de Chim. et de Phys." March, 1865. See also "Carl's Repertorium der Physik," vol. i., p. 142, 1865. It is depicted in Ganot's "Physics" (1879), p. 158.

† Jolly. Ueber eine neue Einrichtung der Quecksilber Luft-Pumpe, "Carl Repert.," i., p. 144, 1866. See also Muller-Pouillet's "Physik" (ed. 1876), vol. i., p. 331; and Mousson's "Physik" (ed. 1879), i., 1878.

‡ Von Babo. See "Muller-Pouillet," i., 233.

§ Poggendorff. "Pogg. Ann.," cxxv., 151.

‖ Alvergniat. See Pellat, "Cours de Physique" (1883), i. 319.

¶ Weinhold's "Physikalische Demonstrationen" (1883), p. 175. See also "Carl's Repert.," ix., p. 78, 1874.

* Kundt und Warburg. "Pogg. Ann.," 526, 1875.

† See Bessel-Hagen. "Wied. Ann.," xii., 435, 1881.

‡ Joule. "Proc. Lit. Phil. Soc. Manchester," xii., 57, 1873; 49. xiii., 58, 1874; 49. xiv., 12, 1875; see also "Scientific Papers," i., 623; also "Catalogue of Loan Collection of Scientific Apparatus," 1876, p. 133.

[JEWELERS' WEEKLY.]

ELI TERRY AND THE FIRST WOODEN CLOCKS.

Up to the year 1720 the few clocks that were scattered through the American colonies were imported from Europe. About that time the manufacture of brass timepieces of the style commonly known as grandfather's clocks was begun, and it soon became a prominent industry throughout New England and in Pennsylvania. But the shrewd people of Connecticut were the first to appreciate the advantages to be gained from the extensive manufacture of the wooden clock.

The origin of the industry is somewhat clouded in obscurity. Between the years 1790 and 1793 several followed the trade, all having reasonable claims to the pioneership, while to Gideon Roberts, of Bristol, is generally conceded that honor, though he never attained any prominence as a clockmaker.

But the name which has become inseparably connected with the wooden clock industry, and which during the early part of the present century was almost a household word throughout the country, is that of Eli Terry. The quiet and puritanical little village of East Windsor, Conn., was the scene of his birth, which occurred in April, 1772. As an apprentice in the shop of Theodore Harland, maker of brass clocks, at Norwich, Conn., he learned the rudiments of the trade which made him famous, and it was not long before he displayed evidences of uncommon mechanical talent.

Eli Terry made his first wooden clock in 1792. It is a "grandfather's," the dial being of cast silvered brass, on which is engraved his name. This clock, which is well preserved and a faithful chronicler of time, is at present in the possession of its maker's grandson, James Terry, of Terryville, Conn. In 1793 the young mechanic went to Plymouth and commenced the manufacture of wooden and brass clocks, but soon discontinued the latter, as the demand for them, as well as the facilities for making them, was limited, while the wooden ones, being much cheaper and quite as good as timekeepers, proved to be far more salable. To convey to the reader an idea of the facilities at this time in the shop, the nursery of the great American clock manufactures, it is sufficient to say that it was an impossible undertaking to commence more than three clocks at one time.

The work—all by hand, of course—was done as follows: The plates were of oak, planed down by hand, and into these the pillars, also turned by hand, were inserted. Strips of cherry wood, planed down to the desired thickness, were used to cut the blanks for the wheels from, the operation being first to prick the centers the correct distance apart, after which the holes for the center of the wheel were bored and the disks cut out by hand. The blanks were then strung on a wire the size of the center holes and moistened with linseed oil to prevent crumbling, after which the teeth were cut out by a hand machine, or, as some claim, with a saw and jack knife. The front or driving side of the teeth was straight, the back side slanting or ratchet shaped. The saw and jack knife were superseded in 1813 by the invention of Asa Hopkins, a machine with three mandrels, by means of which a number of wheels could be finished at one operation. A process similar to the one used to produce the wheels was also pursued in cutting the pinion leaves, which were made from the wood of the mountain ivy, a common shrub of the Connecticut hills. Wires were driven into the ends of the pieces for pivots and the pinion turned to the desired size, and then the leaves were cut.

About the year 1797 Eli Terry invented a clock which registered the difference between mean and apparent time. This clock was not made to any extent, as the cost of making it was excessive, and not being of any ordinary use, a market could not easily be found for it. The Yankee clockmaker worked alone till 1800, when he hired two men to assist him. Three times a year, taking with him a few clocks strapped on the horse back of him, he crossed the Hudson River into the State of New York, then called "the new country," and drummed up trade, delivering the goods as he sold them, in many cases receiving as much as twenty-five dollars for the movement, as at that early period none but the wealthy had cases for their clocks. In 1803, finding that he could sell clocks without being an itinerant, he made arrangements for producing movements on a more extensive scale and availed himself of the advantages of water power. Three years later, his business having increased to such an extent that he found it necessary to sell out his old shop and seek more commodious quarters, he bought an old mill from one Calvin Hoadley, and remodeled it into a factory. This site for years afterward was the residence of Silas Hoadley, who at that time became his apprentice and subsequently his successor to the business.

In 1807 Mr. Terry received a contract from a Waterbury firm to make 4,000 movements, which it took him three years to deliver. The greater part of the first year was consumed in making the parts of the movements. During the second year 1,000 clocks were completed, and in the course of the third the remaining 3,000 saw the light.

The success attending this undertaking was such as to give impetus to wooden clockmaking as an industry, and marks the beginning of the careers of Seth Thomas and of Silas Hoadley as clockmakers. The account books of the firm of Eli Terry show that between the years 1808 and 1810 Seth Thomas was employed in the capacity of joiner.

In the latter year the business, then the leading clock factory in the country, was sold to Messrs. Thomas & Hoadley, Mr. Terry moving to a farm in the central part of the town. It was stipulated in the bill of sale that Mr. Terry should not continue clockmaking, but his restless genius could not long remain inactive, and the famous Terry shelf clock, that soon superseded the old hanging clock, was produced.

The mechanism of this clock was entirely new, being adapted to a short case, both case and movement being dependent on each other, whereas all movements previously made were for long cases, with the case and movement in two distinct parts. In the new clock the weights were allowed to run on each side to the full length of the case. The pendulum, crown wheel, and verge were located in front of the top plate, between the dial and movement, and instead of the verge being attached to an arbor between the plates, as in the hanging clocks, it was hung on a steel pin the same as now used in ordinary pendulum clocks. These changes distinctly marked a new era in the history of clockmaking, and though many important improvements have been introduced since they were made, there is not a clock manufactured that does not retain in some degree the improvements in the shelf clock of 1814.

In 1815, having obtained the consent of Thomas & Hoadley to actively re-enter his old field, Mr. Terry erected a shop on the Naugatuck River, about one mile below his former site, and the following year commenced the manufacture of the shelf clock, having in his employ at the time Chauncey Jerome, who afterward also became famous as a clock manufacturer.

Eli Terry occupied himself for many years with suits against manufacturers who made use of his inventions, the principal suit, against a large company, being withdrawn after several years' litigation and the expenditure of much money.

In 1816 he produced his pillar scroll top case, the first one made in the factory being the work of Chauncey Jerome.

In 1823 Mr. Terry moved to that part of Plymouth now known as Terryville, and, erecting a new factory, associated his sons, Eli, Jr., Henry, and Silas B., with him in the business, under the firm name of Eli Terry & Sons. The father and Henry soon after retiring, the remaining sons started a new factory on the road leading from Plymouth to Terryville. Here the business proved very successful, Eli, the son, realizing to the time of his death, which occurred in 1831, the at that time magnificent fortune of $75,000. His brother Silas B. succeeded him.

After retiring from business Eli Terry still continued to make a few clocks, turning his attention particularly to regulators, though in reality he could not have been called a brass clock manufacturer. Up to the time of his death, which took place in 1852, scarcely a year passed without the world being benefited by some new design in clockwork of his invention, one of particular moment being a peculiar form of gravity escapement, invented in 1830.

Although Eli Terry had received none of the many advantages of early education, health, strength of mind, and sound judgment enabled him to carry to successful fruition the arduous work which his genius cut out for them.

The career of this Yankee clockmaker, whose inventions revolutionized the industry, was a brilliant illustration of his own sturdy maxim: "That knowledge is most beneficial to man which he has direct."

CHARLES S. CROSSMAN.

COMPOSITION FOR SOFTENING AND PURIFYING WATER.—Dry slaked lime, 40 parts, is mixed with sodium carbonate, 50 to 60 parts, or an equivalent quantity of potassium carbonate, phosphate of sodium 2 parts and one part each of potassium permanganate, oxide of manganese, and ammonium carbonate. The compound is added to the water to be softened. "Generally, 1 lb. of the composition will suffice for softening 200 gallons of water."

[Continued from SUPPLEMENT, No. 626, page 10030.]

WOOL HAT MAKING.

PRESSING.—This process serves to put the hat into shape. The entire shaping of the crown is effected in this machine; but the brim is only prepared for the finishing process, which it receives subsequently in another machine. The exact shape which the crown of a hat is to assume depends entirely upon the fashion of the moment, and does not affect the construction of the pressing machine, which is shown in Fig. 13. In this machine hydraulic pressure is applied in the manner shown in Fig. 16. The table, B, receives a metal mould, C, in which the hat is placed, after being first heated, to receive its final set. Previous to the pressing the brim retains all the characteristics of a hand-formed article. It is rough and irregular, and wanting in flatness and finish. A thin plate of zinc, E, is laid upon the hat, and the adjustable press, A, carrying an India rubber bag, D, is laid upon it. Pressure is then applied by the admission of water to the bag, D, and the hat, which was previously of the shape shown at F, is altered to that shown at G.

FINISHING.—Fig. 14 represents a finishing lathe, which is a handy little machine. The shaft of this lathe is vertical, and the chuck has a horizontal position. Motion is imparted either by friction or toothed gearing. The block shown upon the revolving table is a movable one—an exact counterpart, in fact, of the one which is represented lying on its side on the bench. It is clear that any shape of block can be used. The hat being fixed upon this block, and the lathe set revolving, the operator treats first the body with sand paper, to remove all superficial irregularities. It requires considerable dexterity to acquire the nicety of touch requisite to exercise uniformity of pressure upon the revolving surface of the hat, as the oval shape of the body militates against its equal treatment. When a proper surface has been obtained, the sand paper is discarded, and a greased pad, warmed by the small gas stove shown, is substituted. These simple means suffice to put a fine finish on the exterior. It will be seen in the illustration that the chuck is thrown out of gear by a lever sliding upon inclined surfaces, which has the effect of lifting the horizontal disk.

ROUNDING.—By this operation the brim is reduced to the uniform breadth required. The hat is first fixed upon a bracket as represented in Fig. 17, and the width to which the brim is to be cut is regulated by a slide and graduated scale. The rounding, or cutting, is effected by means of two edged disks, which serve the double purpose of turning the hat and cutting off its superfluous and rough edged brim.

CURLING AND IRONING DOWN.—These operations, which constitute the finishing processes as regards the brim, are also performed by hydraulic pressure. Referring to Fig. 18, which represents the apparatus used for this purpose, a table, B, receives the block, D, upon which is laid the plate, E, curved according to the shape required in the brim. The hat is laid into this mould, and a thin metal plate is then laid upon the brim to prevent any alteration of shape in that part. The upper press, A, carrying an India rubber bag, C, is thereupon lowered into position. Pressure is then applied, and the bag, C, takes the shape shown in Fig. 19, where it will be seen the operation of curling has been accomplished. The hat, previous to being placed in this mould, has been heated, and the cooling effect of the water during curling tends to harden the hat, and fix the curl which has been given while in that position. In order to improve the shape of the brim, the curl is then flattened by the press shown in Fig. 20, which is worked by hand, and consists of a hollow box, heated by means of gas at A, and in order to prevent the heat having any detrimental effect upon the body of the hat, it is lined with an annular casing, B, through which cold water is constantly flowing. A patent has been recently taken out for another machine for this purpose, but it is not yet extensively used by hat manufacturers.

PARING.—The brim now receives its final dressing at the hands of the "parer." The entire circumference is first carefully trimmed with a sharp chisel, and the smoothness of the edge is then secured by the use of a miniature plane. As generally practiced, there is not the slightest attempt at method in the first of these processes. The operator merely guesses at the width, and slices away the felt accordingly. Recently, however, a paring machine, which is found to answer the purpose admirably, has been introduced.

TRIMMING.—The work of trimming is very light, and affords congenial employment to a considerable number of women, who receive comparatively high wages for the labor, and may in some cases perform the work at home. The operations included under this head comprise binding, putting on the galloon band, inserting the silk lining, where that is used, and sewing in the leathers. Machinery is only employed in the case of low priced work, while the better class goods are trimmed by hand.

SHAPING.—The handling to which the hat was subjected when in the hands of the trimmer leaves it in need of a finishing touch, so as to assume the form required. This operation is performed by means of a screw press (Fig. 15) with a movable table, carrying dies of the form required. The hat, after having been heated, is laid in the die, and the table is then moved into the working position. The upper plate is then lowered, and pressure is applied by moving a hand lever connected to a shaft, which carries a pair of cams for raising the table and frame bodily.

VELOURING OFF.—The little lathe shown in Fig. 14 is also used for this, the final operation, the object of which is simply to put a finish on the felt. A gas heated pad, charged with a portion of a tallow candle, is applied, to give to the hat a glossy and finished surface. The completed article is then carefully wrapped in tissue paper, and packed into a bandbox previous to being sent to its destination.—*Industries.*

FIG. 13.

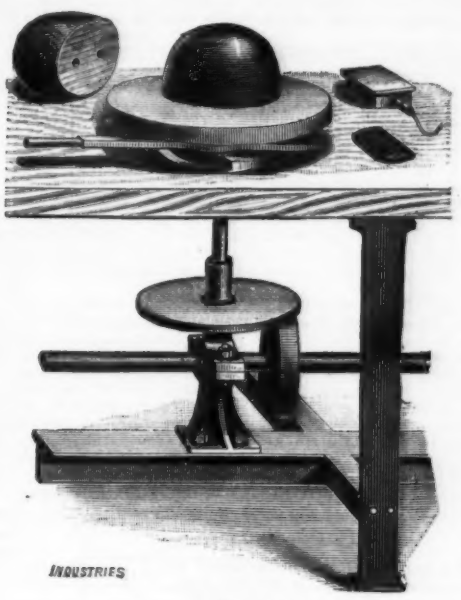


FIG. 14.

FIG. 15.

WOOL HAT MAKING.

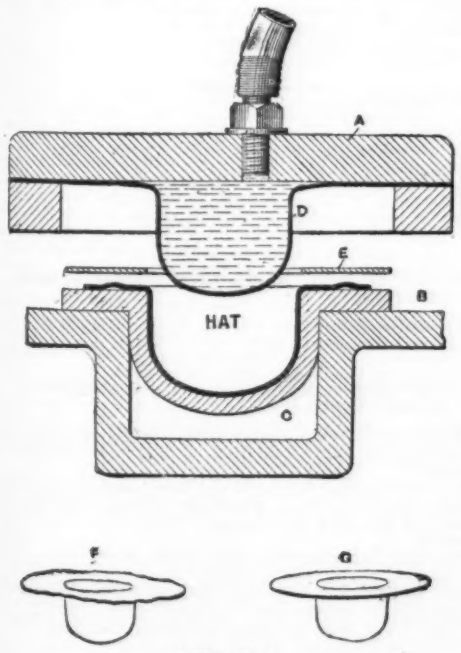


FIG. 16.

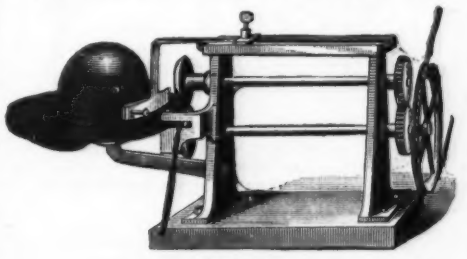


FIG. 17.

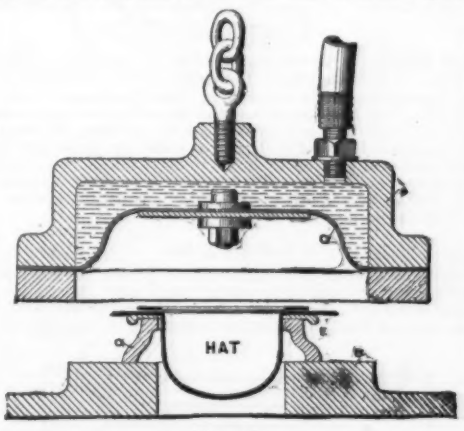


FIG. 18.

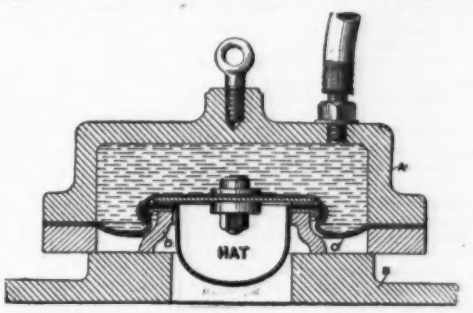


FIG. 19.

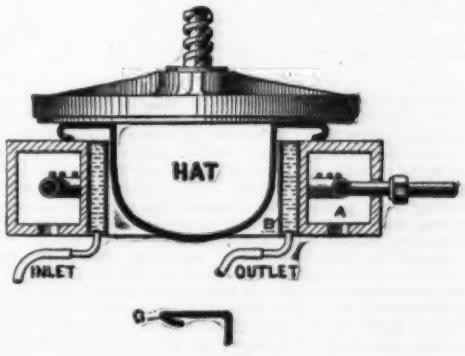


FIG. 20.

POLISHING METALS AND POLISHING AGENTS.

METALS are polished either by burnishing or buffing. The process of burnishing consists in rubbing down all the minute roughness by means of a highly polished steel or agate tool—none of the metal being removed. The action of the burnisher appears to depend upon two circumstances. First, that the harder the material to be polished, the greater luster it will receive. The burnisher is, therefore, commonly made of hardened steel, which exceeds in hardness nearly every metallic body. And, secondly, its action depend son the intimacy of the contact between the burnisher and the work; and the pressure of the brightened burnisher being, in reality, from its rounded or elliptical section exerted upon only one mathematical line or point of the work at the time, it acts with great pressure and in a manner distinctly analogous to the steel die used in making coin, in which latter case the dull but smooth blank becomes instantly the bright and lustrous coin, in virtue of the intimate contact produced in the coining press between the entire surface of the blank and that of the highly polished die.

It by no means follows, however, that the burnisher will produce highly finished surfaces, unless they have been previously rendered smoooth and proper for the application of this instrument; as a rough surface, having any file marks or scratches, will exhibit the original defects, notwithstanding that they may be glossed over with the burnisher, which follows every irregularity. And excessive pressure, which might be expected to correct the evil as in coining, only fills the work with furrows or produces an irregular indented surface, which, by workmen, is said to be *full of gutters*.

Therefore, the greater the degree of excellence that is required in burnished works, the more carefully should they be smoothed before the application of the burnisher, and this tool should also be cleaned on a buff stick with crocus immediately before use, and it should in general be applied with the least degree of friction that will suffice. Cutters mostly consider that burnishers for steel are best rubbed on a buff stick with the finest flour emery. For silver, however, they polish the burnisher with crocus, as usual. Most of the metals, previously to their being burnished, are rubbed with oil, to lessen the risk of tearing or scratching them, but for gold and silver the burnisher is commonly used dry, unless soap and water or skimmed milk are employed; and for brass furniture, beer or water, with or without a little vinegar, is preferred for lubricating the burnisher.

Buffing is performed by rubbing the metal with soft leather, which has been charged with very fine polishing powder. The rubbing is sometimes done by hand, but more frequently the buff is made into a wheel which revolves rapidly in a lathe, and the work is held against it.

The polishing powder that is selected must be chosen with special reference to the metal that is to be buffed. Thus, for steel and brass, the best polishing powder is crocus or rouge, which may be purchased from any material dealer, or may be made by exposing very clean and pure crystals of sulphate of iron to heat, according to the directions given hereafter under the head of *Polishing Agents*. The hardest part of the rouge must be selected, and great care must be taken to have it clean and free from particles of dust and sand, which would inevitably scratch the article to be polished, and render it necessary to again repeat all the previous processes of filing, grinding, etc.

Soft metals, like gold and silver, may be polished with comparatively soft powder, such as prepared chalk or putty powder (oxide of tin).

When metals are to be polished in the lathe, the process is very simple. After being turned or filed smooth, the article is still further polished by means of fine emery and oil, applied with a stick, and in the case of rods or cylinders, a sort of clamp is used, so that great pressure can be brought to bear on the part to be polished. The work must be examined from time to time, to see that all parts are brought up equally to the greatest smoothness and freedom from scratches, and as fast as this occurs, polishing powder of finer and finer quality is used, until the required finish is attained.

In polishing metals or any other hard substances by abrasion, the great point is to bring the whole surface up equally. A single scratch will destroy the appearance of the finest work, and it cannot be removed except by going back to the stage to which it corresponds, and beginning again from that point. Thus, if in working with a smooth file we make a scratch as deep as the cut with a bastard file, it is of no use to try and remove this scratch with the smooth file. We must go back, and, taking a bastard file, make the surface as even as possible with it, and afterward work forward through fine files and polishing powders.

POLISHING AGENTS.

Nothing is more necessary to the successful use of polishing powders than equality in the grain. Fine dust clogs the action of coarse grinding powders, and prevents them from cutting with rapidity the object to be ground; coarse particles mixed with fine polishing powder scratch the article to be polished, and render grinding and polishing necessary again. To secure fineness and uniformity, no process equals that of elutriation, which is thus performed:

Suppose it were desired to separate the ordinary flour of emery into three different degrees of fineness. Take three vessels (such as tin pails or glass jars), and mix the emery with a large quantity of water—say one quart of water to one and a half ounces of emery. Stir the mixture until the emery is thoroughly diffused through the liquid, and allow to stand five minutes. By this time all of the heavier particles will have settled, and on pouring the fluid into a second jar, only the finer portion will be carried over. So continue to wash the first residuum until nearly all the particles have subsided at the end of five minutes, and the water is left comparatively clear. You will now have the coarse portion, No. 1, by itself.

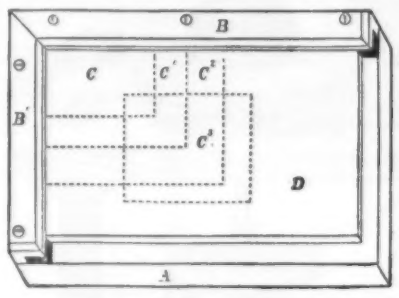
So, from the sediment collected from the washings of No. 1, you may collect a portion, No. 2, having a second degree of coarseness. The last and first will be obtained by letting the final washings stand ten or fifteen minutes, pouring off the liquid and allowing it to settle.—*Horological Journal.*

PHOTO WRINKLES.

By ALEXANDER KELLAR.

MOUNTING BOARD.

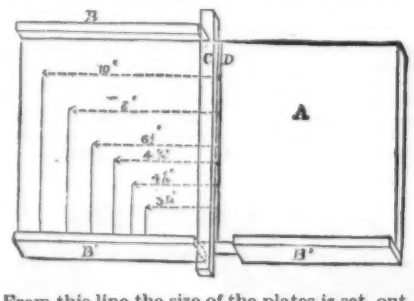
THIS consists of a flat board, A, upon which are screwed the strips B B¹ at right angles to one another. Each of those strips has a rabbet cut out of its under side about half an inch deep, so as to allow the glass, D, to slip beneath. On this board a piece of paper can be pasted, on which the sizes of the mounts should be marked—C, C¹, etc.—care being taken that one edge and the bottom comes exactly under the edges of B B'. D is a piece of glass which can be moved to and fro



in the rabbets already referred to. In using this board have the print surface dry. Put one of them on an old negative, face down, and paste, then put it on the glass, D, still face down, and as nearly as possible to the lines. Move the glass till the print shows an equal margin all round the lines. Then take the mount, and, keeping it against the edges of B B', press it down, and if care has been taken, you will have a perfectly mounted print. Keep the glass dry and clean, and you will not damage the most delicate mount.

GLASS CUTTING BOARD.

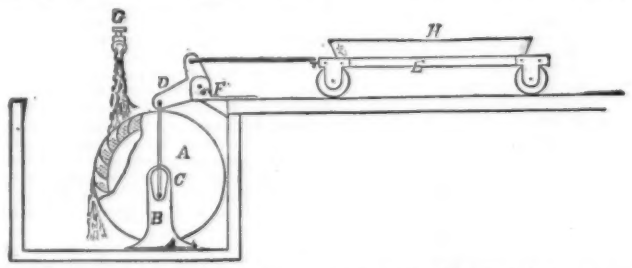
A is a flat board, on the edges of which are screwed the projecting pieces, B, B', B². C is a piece of wood bearing against the ends of B and B', and which forms the straight edge for the cutter or diamond. D is the line which the diamond will make when held against



C. From this line the size of the plates is set out and marked on the board, or a stop is fixed, and by two cuts you have a glass exactly square, provided the board has been made square in the first instance.

ROCKING MACHINE.

I have a water wheel in my sink, supported on two standards, B. On this wheel is fixed a crank, C, connected to a bell crank, D, supported by a bearing, F, which is, in its turn, connected to the carriage, E, supporting my developing dish, H, resting on four



small wheels. Over the water wheel is a tap or a piece of tube which discharges its water into the buckets of the wheel and sets it in motion. The developer in the dish, H, is by this means carried from end to end, and slow development is deprived of its terrors. I have left an underexposed plate in the dish for thirty minutes, and found it increasing in density whenever I had a look at it. This machine can also be used for toning and fixing prints, keeping them in constant motion without handling.

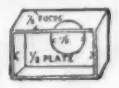
PRINTING FRAMES.

My improvement consists of two pieces of zinc, or other metal, cut out as in the shaded part in the annexed drawing. Mark the side of the frame where the flaps join at the hinges, make a saw cut in the side of

the frame, and drive the zinc pieces in tight, when they will come between the joints, and prevent any movement of the flaps. The stops at one end of the frame will have to be taken out so as to slip the negative into position.

VIEW FINDER.

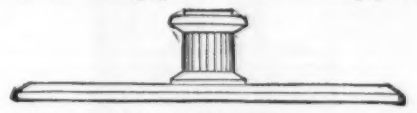
This is simply a small box, either of metal or cardboard, with an open end. This end and the length of the box should be a fractional part of the lens focus, and of the size of the plate, say ⅛ inch. In the closed end of the box is cut a hole about ⅜ inch diameter. On holding this end to the eye you can readily see all that your lens will take in. The box which I have is for 9 inch focus and 7⅗×5 plate. It is strongly made, only weighs three drachms, and can easily be carried in the pocket. It is always at hand to tell if a "bit" can be



taken in the proposed picture. Many a time it has saved me the trouble of unpacking.

TRIMMING PRINTS WITH A CUTTING GLASS.

This work is rendered easy by attaching a handle to the beveled cutting glass. I stick an empty bobbin



or a cork on the glass with elastic glue, and all trouble vanishes.—*The Camera.*

A NEW PLATINOTYPE PROCESS.

MR. HERMANN C. GUNTHER, in the *Photographic News*, gives the following particulars about an important improvement in the platinotype process devised by Captain Pizzighelli.

Probably all photographers are sufficiently familiar with this process to know that in printing the platinotype paper the image which appears is not brown or purple, but of a faint grayish yellow color, and therefore it is rather difficult to judge whether a print has had sufficient exposure in the frame, as may be done in the case of albumenized paper.

To remove this drawback, which to some degree has been prejudicial to the popularity of this printing process, Capt. Pizzighelli, to whom we are indebted for much valuable information on the subject of platinum printing, has made many experiments, but only recently has he succeeded in finding out a method of producing platinotypes directly in the printing frame without development.

The principles of this method are the following:

1. If to the sensitizing solution certain vehicular substances are added, this solution will be prevented from penetrating into the body of the paper.

2. If to the sensitizing solution one of those substances which serve as developers is added in the very beginning, a reduction of the plantinum salt takes place directly in the printing frame by atmospheric influences.

The advantages of the new process are, therefore, very important, as there is no longer a necessity for a preliminary preparation of the paper, and as you can judge of the exposure as accurately as with silver. Besides this, the development of the paper is entirely omitted. A simple, short washing of the prints, first in acidulated, then in ordinary water, is sufficient for finishing the pictures.

Sensitizing the Paper.—For coating, Rives or Saxe paper may be used, either glossy or with a matt surface.

Solutions of gum arabic and of arrowroot have been found the best vehicular substances for the sensitizing liquid, but the former has proved to give better results than the latter. They are mixed in the following manner:

I.—Gum arabic	50 grammes.
Distilled water	100 c. c.
II.—Arrowroot	2 grammes.
Distilled water	100 c. c.

The latter is boiled in the usual manner to paste. Before use mix:

Sensitizing liquid	2 parts.
Gum solution I	1 part.
Or,	
Sensitizing liquid	1 part.
Arrowroot paste II	1 "

The mixture is well stirred until it forms an entirely homogeneous liquid, and then it is filtered through muslin.

The coating and drying of the paper, and its storing in tin cylinder boxes, in which dry calcium chloride is placed, is the same as in the case of the old platinotype process.

The sensitizing solution is prepared as follows: To the normal ferric oxalate solution is added in the dark room, and keeping the dish rocking, as much of neutral ammonium or sodium oxalate as will just dissolve at the ordinary temperature. For this purpose will be required of the above named salts:

To normal ferric oxalate solution	100 c. c.
Neutral ammonium oxalate	18 to 20 grammes.
Or to normal ferric oxalate solution	100 c. c.
Neutral sodium oxalate	15 to 18 grammes.

By formation of the corresponding double salt the brownish gray color of the ferric oxalate changes to a beautiful emerald green. If the solution begins slightly to darken, this will indicate that the saturation is completed. As soon as this takes place, no more ammonium or sodium oxalate should be added. Keep the dish rocking for some further time, allow to set, and then filter.

The solution may be mixed as follows:

Chloro-platinite of potassium solution (1 part to 6 parts of water)	24 c. c.
Ammonia ferric oxalate solution, or sodium ferric oxalate solution	23 "
Gum solution I	23 "

If ammonium oxalate be added, the prints will be of a more bluish tone; while, by the addition of sodium oxalate, they are rendered more brownish. The former gives somewhat softer prints than the latter. As to the sensitiveness, there has been found no marked difference between the two salts.

No definite statements can as yet be made regarding the keeping qualities of the new paper, as since the perfection of the new process only a few weeks have elapsed; but the samples kept within this period remained unchanged.

Chlorate of potash may be added with the effect of increasing contrast, and this may be done in the same manner as with the old platinotype process.

The above given quantity of the sensitizing liquid is sufficient for five sheets of the ordinary size. The exposure of the paper no longer offers any difficulty. As the results will be more satisfactory if the paper possesses a certain degree of surface moisture (as in the case of silver printing), it will be well to take the sheets to be worked, a few hours before use, off the tin cylinder, and to hang them up in the dark room. In placing the paper on the negative, it is, with this process, of course, not necessary to place behind it a sheet of vulcanized India rubber sheeting or a piece of waxed paper.

In printing and finishing the picture, the following modifications are allowable:

1. The printing is carried on until the image has appeared in all its parts. The picture when taken out of the frame should not be darker than what it should be when finished.

2. The printing is only continued until the picture is in general visible, but the delicate half tones are still wanting. The picture is taken out of the frame and kept separately. In about half an hour to two hours' time the picture will be finished by itself, as the reduction of the platinous chloride, once introduced, is continuous in the dark; or, the picture is developed out with a cold diluted solution of sodium carbonate.

A good solvent is the following:

Saturated solution of soda carbonate	5 c. c.
Distilled water	100 "

Into this solution is immersed the picture and allowed to remain until all the delicate details are to be seen, which will require only a few seconds.

3. Printing is continued about as far as with the ordinary platinotype paper, *i. e.*, until only those parts of the negative which are clear glass, or nearly so, are distinctly visible. Then development is carried on as with the ordinary platinotype paper.

The pictures printed according to one of the methods 1, 2, or 3, are placed into

Hydrochloric acid	1 c. c.
Water	80 "

and allowed to remain there until the yellow color of the ground of the paper has disappeared. Then they are, for ten or fifteen minutes, washed in two or three changes of water.

[PREPARATION OF THE FERRIC OXALATE SOLUTION.

For the preparation of this solution of ferric oxalate the following operations are necessary:

1. Manufacturing the ferric hydrate.
2. Dissolving that substance in oxalic acid.
3. Determining the amount of iron and of oxalic acid contained in this solution.
4. Diluting and acidulating the same.

The method of preparing ferric hydrate is generally well known, but for the sake of completeness we will give a brief description of it. Ferric chloride, 500 grammes, is dissolved in from five to six liters of water, and when the solution has been brought to the boiling point, solution of soda is added, until it gives with litmus paper a distinctly alkaline reaction. For this purpose about 250 grammes of caustic soda will be found necessary. The precipitate is then washed with hot water by decantation, until the wash water is no longer alkaline. It is next placed in a cloth, and by pressure freed from the greater part of the water. With the ferric hydrate thus obtained, which ought to have a sirupy consistency, there should be mixed about 200 grammes of finely crystallized oxalic acid, and the mixture be then left to itself for a few days at a temperature of not more than 30° C, and in a place completely protected from the light. Under these circumstances the formation of ferric oxalate will go on steadily.

Some persons recommend the promotion of this process by digesting the mixture for some time at a high temperature. This we are decidedly opposed to, since by heating for even a very few hours to 50° or 60° the salt will be partially reduced to a ferrous oxalate. At the commencement the solution has a pure green color, by continued digestion it turns yellowish green, and finally greenish brown. When this moment has arrived, the remaining ferric hydrate should be filtered off, and the solution be submitted to a quantitative chemical analysis.*

Although the determination of the amount of iron and oxalic acid contained in the solution is one of the simplest of analytical operations, we tried at first to dispense with it. Closer investigation, however, proved to us how necessary it is to confine the relations between rather narrow limits, in order to insure the success of the platino-ferric process. Now as ferric oxalate cannot be prepared in a stable form, so as to have a constant composition, there remains no other way than that of determining the composition of the solution by analysis, and then diluting it to the required degree. Further, it should be noted that any quantity of the solution may be prepared at once, and then kept in stock.

From the analysis we ascertain the quantity of ferric oxalate contained in 100 c. cm. of the solution, as well as any slight excess of oxalic acid which happens to be present. The liquid is then diluted with so much distilled water that every 100 c. cm. of it may contain 20 grammes of ferric oxalate [$Fe_2(C_2O_4)_3$]. Crystallized oxalic acid is then added until, with the free acid already in the mixture, that substance amounts to from 6 to 8 per cent. of the ferric oxalate already in the solution—the normal ferric solution.

By publication of his experiments Capt. Pizzighelli undoubtedly rendered a great service to the many friends of the platinotype process, which stands now as one of the simplest and most attractive photographic printing processes.

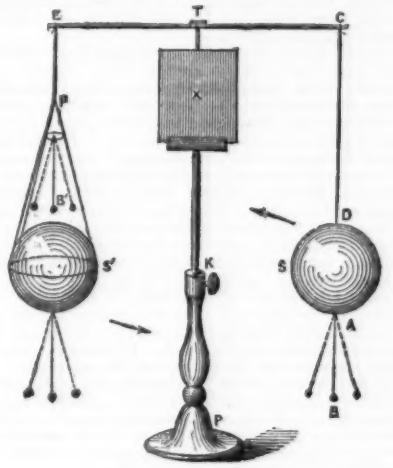
I hope that what I have given here has been sufficient to enable those who may feel so disposed to make a few successful experiments with this beautiful and so much improved process.

* To perform this analysis a few c. centimeters of the solution are measured off, and the oxalic acid then determined from measure by means of permanganate of potash. The amount of iron in the same liquid may be ascertained in the same way, after reduction by means of zinc. But it is perhaps more convenient to determine by weight the iron in a separate portion of this solution. This can be done by evaporating, heating to redness, incinerating with nitrate of ammonia, and weighing the ferric oxide which remains.

THE GALIOSCOPE.

THE annexed engraving represents a simple and inexpensive apparatus devised by Mr. A. Boillot for repeating Foucault's well known pendulum experiment on a small scale, and showing that the plane of the oscillations of a pendulum preserves a position independent of the rotation of the sphere to which it is attached.

The apparatus, which Mr. Baillot calls a *galioscope*, consists of rubber ball, S, four inches in diameter, from which is suspended a small ball, B, by means of a thread, AB, about four inches in length. The ball, S, is supported by a thread, CD, fixed at the point, D, diametrically to A, the suspension point. These two points, D and A, are the poles. The thread, CD, is eight or nine inches long, and is fastened by its upper extremity to the end of a horizontal rod, CE, balanced at E by another sphere, S, from which hangs another pendulum identical with the first. The rod, EC, is capable of being revolved through clockwork around the vertical axis, TK. If now the pendulum be set in



THE GALIOSCOPE.

motion, and the entire affair be made to revolve around the axis, TK, it will be seen that in the double motion of the spheres the plane of the pendulums' oscillations preserves a constant direction, the vibrations being unaffected by the motion of the spheres.

Foucault's experiment, which was performed at Paris, of which the latitude is 48° 50' 49", gave 31 h. 52 m. 27 s. as the time for a complete revolution of the vibrating plane of the pendulum. This time, expressed by

$$\frac{24 \text{ h.}}{\text{Sin L}}$$

(L being the latitude), becomes twenty-four sidereal hours at one of the poles of the earth. This time is infinite at the equator, or Sin L= ; that is to say, that for this circle the direction of the plane of oscillations is invariable with respect to objects placed upon the surface of the globe. This fact may be verified experimentally by means of the galioscope, by revolving the sphere around a horizontal axis.

TELESCOPES: THEIR HISTORY AND THE DISCOVERIES MADE WITH THEM.

GALILEO is popularly regarded as the inventor of the telescope, since in his hands it performed such prodigies. But he himself says he got the idea of combining two lenses, to produce an enlarged image of an object, from Holland.

There is no doubt that the telescope was invented there by either Metius, Lipperhey, or Jansen, for the States General in November, 1608, refused to grant a patent for such a device on the ground that it was already known and in use for military purposes. Galileo heard of this invention in 1609, and at once made a telescope, which he exhibited at Venice. It is noteworthy that the telescope was invented for use in war; its applications in science began with Galileo's return to Florence. Here he made several instruments, some of which I have myself seen. They were on the principle of the ordinary opera glass, but they were single barreled. The most powerful only magnified some thirty times, and its vision was far from good, since the art of grinding lenses was in its infancy.

To understand the revolution that Galileo's discoveries made, we should comprehend the times in which he lived.

The sun was then regarded as a pure fire and immaculate; but Galileo found spots upon its disk, and showed that it rotated on an axis. Perhaps, then, it was the earth after all that rotated on an axis, and not the whole universe that turned around nightly to display the glory of the stars to contemplative men.

The number of planets was then seven, the sun, the moon, Mercury, Venus, Mars, Jupiter, Saturn. But in January, 1610, Galileo found that Jupiter was accompanied by satellites in nowise different from the moon. The sacred number seven had become eleven, and Pythagoras had not constructed any harmonies with eleven as a basis. There were not eleven studies in the curriculum.

The number of the stars was limited—had not Ptolemy catalogued them?—and the milky way was just a shining path through heaven. But Galileo's telescope showed innumerable stars which the eye had never seen, and introduced unknown complexities in the place of the simple order which had reigned before.

The planets themselves were no longer bright points of light, but worlds with disks and faces like the sun and moon. Saturn—aged Saturn—had no servitors to help him on his journey.

Venus in particular resembled the moon in the most intimate way. Her disk, which at one time was round, became a half circle, and finally a thin crescent like the new moon. In doubt as to the exact significance of this, Galileo recorded his doubts and concealed his discovery in an anagram as follows:

"Hæc immatur a me jam frustra leguntur o. y." That is to say, "These things, as yet not ripe, are vainly gathered by me." His discovery was hidden in this sentence, also, for when its letters are transposed it makes the declaration: "Cynthiæ figuras æmulatur mater amorum"—that is, "Venus imitates the phases of the moon."

The first observation of Galileo on Venus was made in September, 1610, and the result of it was to prove that the planets revolved round the sun and not round the earth. For centuries, man and the earth on which he lived had been considered the true center of the universe, which, therefore, was made for him. But if Venus had phases like the moon, she shone, like the moon, by virtue of the sun's reflected light; and it took but a little calculation to show that the observed phases changed as Venus revolved round the sun, and were in no way dependent upon the position of the earth.

Here, at one blow, the "optic tube" which Milton saw when he visited Galileo at Florence had overturned the theories of centuries and had directed human inquiry along new channels—along the channels, in fact, which the world is following to-day. Kepler, Newton, Cuvier, Lyell, Huxley, Darwin, would have been impossible if Galileo had not struck this first blow.

It is important to notice that it was not the observation that Galileo made, but the interpretation of the observation, that did the work. It was, after all, by a man that man was dethroned as the king and center of the universe.

It is precisely the same to-day. Powerful telescopes and grand observatories are of no use unless the facts which they reveal are co-ordinated and interpreted by competent observers. The man is more than half the telescope, and often a discovery has been chiefly valuable, not in and for itself, but as a means to free some master mind and to give it opportunity. I never see the planet Uranus without remembering that its almost chance discovery gave Herschel thirty years of leisure, and that the study of its motions by Adams and Le Verrier led not only to the discovery of Neptune, but also devoted the whole lives of two great philosophers to the service of mankind.

The glasses that were available to Galileo and his successors were of poor quality and of small dimensions. The largest pieces were only five inches or so in diameter. These were made into object glasses by Huyghens (about 1670), and to avoid the aberrations of form and color the focal length of these had to be forty, fifty, even one hundred feet. The mechanical difficulties of handling such long telescopes were (and are) great. Yet in the hands of Cassini, Huyghens, and others great discoveries were made by them. The real nature of Saturn and his ring was unfolded; satellites to Saturn were discovered; the nebulæ were for the first time seen; the surfaces of planets were studied.

The difficulties in procuring a glass led Newton to the construction of a reflecting telescope in 1668. This was an inch in aperture and magnified thirty-nine times, and its mirror was made of an alloy of copper and tin, which took the place of the glass objective. Nevertheless, the long and clumsy refractors of Huyghens held their own until Hadley (1723) constructed a reflector only five feet long, which was superior to the best of the refractors.

In the last half of the eighteenth century Short constructed admirable reflectors, and Herschel began the manufacture of others which surpassed even these. About 1785 Herschel's twenty foot reflectors had an aperture of eighteen inches and were instruments of extreme precision.

The advantages of reflectors are found in their cheapness and in the fact that, supposing the mirrors perfect in figure, all the rays of the spectrum are brought to one focus. Thus the reflector is suitable for spectroscopic or photographic researches without any change from its ordinary form. This is not true of the refractor, since the rays by which we now photograph (the blue violet rays) are, in that instrument, owing to the secondary spectrum, brought to a focus slightly different from that of the yellow and adjacent rays by means of which we see.

Reflectors have been made as large as six feet in aperture, the greatest being that of Lord Rosse, but those which have been most successful have hardly ever been larger than two or three feet. The smallest satellite of Saturn (Mimas) was discovered by Sir William Herschel with a four foot speculum, but all the other satellites discovered by him were seen with mirrors of about eighteen inches in aperture. With these the vast majority of the other discoveries were made.

The satellites of Neptune and Uranus were discovered by Lassell with a two foot speculum, and much of the work of Lord Rosse has been done with his three foot mirror, instead of his celebrated six foot one. From the time of Newton till quite recently it was usual to make the large mirror or objective out of speculum metal, a brilliant alloy liable to tarnish. When the mirror was once tarnished through exposure to the weather, it could be renewed only by a process of polishing almost equivalent to figuring and polishing the mirror anew. Consequently, in such speculums, after the correct form and polish were attained, there was great difficulty in preserving them. In recent years this difficulty has been largely overcome in two ways: (1) By improvements in the composition of the alloy, by which its liability to tarnish under exposure is greatly diminished, and (2) by a plan proposed by Foucault, which consists in making, once for all, a mirror of glass, which will always retain

its good figure, and depositing upon it a thin film of silver, which may be removed and restored with little labor as it becomes tarnished.

In this way one important defect in the reflector has been avoided. Another great defect has been less successfully treated. It is not a process of exceeding difficulty to give to the reflecting surface of either metal or glass the correct parabolic shape by which the incident rays are brought accurately to one focus. But to maintain this shape constantly, when the mirror is mounted in a tube and when this tube is directed in succession to various parts of the sky, is a mechanical problem of extreme difficulty. However the mirror may be supported, all the unsupported points tend by their weight to sag away from the proper position. When the mirror is pointed near the horizon, this effect of flexure is quite different from what it is when pointed near the zenith.

As long as the mirror is small (not greater than eight to twelve inches in diameter), it is found easy to support it so that these variations in the strains of flexure have little practical effect. As we increase its diameter up to forty-eight or seventy-two inches, the difficulties become almost insurmountable. In fact, no good mirror has been made larger than thirty-six inches. Mr. Common, of England, is now engaged on a large reflector of sixty inches aperture, and if any one can make such a mirror successful, it is he. But up to this time his thirty-six inch mirror is the largest reflector which has been really successful.

Although refractors of the simple form used by Huyghens were wonderful instruments in their day, yet they would not now be regarded as serving any of the purposes of such an instrument, owing to the aberrations with which a single lens is affected. When ordinary light passes through a simple lens it is partially decomposed, the different rays coming to a focus at different distances. The focus for red rays is most distant from the object glass, and that for violet rays nearest to it. Thus arises the chromatic aberration of a lens. But this is not all. Even if the light is but of a single degree of refrangibility, if the surfaces of a lens are spherical, the rays which enter the edges of the lens will come to a focus quicker than those which enter near the center. This latter defect of spherical aberration was partly cured by the enormously long-focused lenses constructed by Huyghens.

But of the two defects, the chromatic aberration is much the more serious; and no way of avoiding it was known until the latter part of the last century. The fact had, indeed, been recognized by mathematicians and physicists, that if two glasses could be found having very different ratios of refractive to dispersive powers, the defect could be cured by combining lenses made of these different kinds of glass. But this idea was not realized until the time of Dolland, an English optician who lived during the last century. This artist found that a concave lens of flint glass could be combined with a convex lens of crown of double the curvature in such a manner that the dispersive powers of the two lenses should neutralize each other, being equal and acting in opposite directions. But the crown glass having the greater refractive power, owing to its greater curvature, the rays would be brought to a focus without dispersion. Such is the principle of the construction of the achromatic objective. As now made, the outer or crown lens is double convex; the inner, or flint one, is generally nearly plano-concave.

The struggle for supremacy between reflectors and refractors, which began before the time of Herschel (1750), is not yet concluded, but by the invention of the achromatic combination of Dolland the refractor was placed on equal terms. About 1800 the 4-inch telescopes of Dolland were successfully competing with much larger reflectors of that day.

In 1830 the manufacture of glass had improved so far that objectives of 9 in. and more could be made, and several of about that size were constructed for the observatories of Dorpat, Rome, and Munich by Fraunhofer, the successor of Guinand. There was nothing which could be seen by the 40 ft. reflector of Herschel which was not equally well seen by means of these far more convenient instruments. The form of mounting was also vastly improved and the permanence of their adjustments was a capital advantage.

When Fresnel invented the modern system of light-house illumination, the demand for good glass became very great, and every advance made in the service of the arts was quickly utilized by science, which had given the original impetus. The refractor became the standard instrument, while the reflector did wonders in the hands of a few observers, who made their own instruments and who knew how to obviate every one of the many difficulties in their use.

The 15 in. telescopes of Harvard College and of St. Petersburg remained the most powerful refractors from 1845 to 1861. In the meantime the 2 ft. reflector of Lassell had made numerous and important discoveries. The satellites of Uranus and Neptune were discovered by its aid, and Mr. Bond, at Harvard College, anticipated Lassell's discovery of the seventh satellite of Saturn by a few hours only.

The refractors made by Alvan Clark (1840–60) were of extreme excellence, and some of his smaller telescopes (7 and 8 in.) had found their way to England. In 1861 the Clarks made a telescope of 18 in. aperture. In 1873 the 26 in. refractor of the naval observatory at Washington was mounted, and soon proved itself to be a master work. No other telescope in the world has done so much and so brilliant work in the fifteen years just passed. A duplicate of this was made by the Clarks for the University of Virginia, one nearly as large (23 in.) for Princeton, then a 30 in. for St. Petersburg, and finally the 36 in for the Lick observatory.

The most important matter in a telescope is perfect definition, *i. e.*, neatness, accuracy in the image of the object looked at. This allows the use of high magnifying power, provided there is light enough collected by the object glass. It is precisely in this respect that the Clark telescopes are pre-eminent.

It is not merely by magnifying that the telescope assists the vision, but also by increasing the quantity of light which reaches the eye from the object at which we look. Indeed, should we view an object through an instrument which magnified, but did not increase the amount of light received by the eye, it is evident that the brilliancy would be diminished in proportion as the surface of the object was enlarged, since a constant amount of light would be spread over an increased surface; and thus, unless the light were brilliant, the object might be so darkened as to be less plainly seen than with the naked eye. How the telescope increases the quantity of light will be seen by considering that, when the unaided eye looks at any object, the retina can only receive so many rays as fall upon the pupil of the eye. By the use of the telescope as many rays can be brought to the retina as fall on the entire object glass. The pupil of the human eye, in its normal state, has a diameter of about one-fifth of an inch; and by the use of the telescope it is virtually increased in surface in the ratio of the square of the diameter of the objective to the square of one-fifth of an inch. Thus, with a 2-inch aperture to our telescope, the number of rays collected is 100 times as great as the number collected with the naked eye.

If the brightness of a star seen with the eye alone is 1, with a 2-inch telescope it is 100 times as bright, 4-inch telescope it is 400 times as bright, 8-inch telescope it is 1,600 times as bright, 16-inch telescope it is 6,400 times as bright, 32-inch telescope it is 25,600 times as bright, 36-inch telescope it is 32,400 times as bright. That is, stars can be seen with the 36 inch telescope which are 30,000 times fainter than the least stars visible to the naked eye. While the magnifying power which can be successfully used on a 5-inch telescope is not above 400, the 36-inch telescope will permit a magnifying power of more than 2,000 diameters on suitable objects; stars, for example. This power cannot be used on the moon and planets with real advantage for many reasons, but probably a power of 1,000 or 1,500 will be the maximum. The moon will appear under the same conditions as if it were to be viewed by the naked eye at a distance of say 200 miles. This is the same as saying that objects about three hundred feet square can be recognized. So that no village or great canal, or even large edifices, can be built on the moon without our knowledge. Highly organized life on the moon will make itself known in this indirect way, if it exists.

If one were looking at the earth under the same conditions, the great works of hydraulic mining or the great operations on Dakota farms or California ranches would be obvious.

The great enemy to large telescopes, and indeed to all telescopic vision, is the unsteadiness of our own atmosphere. It is just in this respect that the site for the Lick observatory has been well chosen. We are sure that we can use higher magnifying powers to advantage there than at other stations. Whatever advantages belong to large telescopes (and there are many), we shall come nearer to realizing there than at other sites. We have lately heard much of the disadvantages and failures of large telescopes. The time for using the great telescope at Mount Hamilton is now so close at hand that it is far more satisfactory to wait a few months for actual results than to dogmatize about what these results are to be. If we stop to inquire what results we should like to hear of, we may see that some of them are unlikely to be reached or impossible of attainment. Mr. Lick wished to prove or disprove the existence of animals in the moon. If there are any city-building animals, we shall know this indirectly. We should all like to know if Neptune is the last planet of our system, but this is probably not a question for large telescopes at all, but one for photographic maps of the sky to settle. If there are more faint satellites, we ought to be able to see them, and so with many other similar problems.

But, leaving such questions to one side for the present, let us consider the subject in another way. The whole earth is dotted with powerful telescopes in the hands of able astronomers. There is not a single telescope so powerful as our own; there is no one so advantageously situated; some of our observers are the equal of any on the globe. There will be a natural limit to the performances of other telescopes, and that limit will yet remain within our powers. In this very simple way the Lick telescope will become the final arbiter in very many important and difficult questions. If it does no more than this, and if it does this well and faithfully, it will justify its existence and all the labor that it has cost. What it does more than this will be still more to its credit.

I have left myself little space to speak of one of the chief adjuncts of the great instrument—namely, the photographic lens of thirty-four inches aperture, which Mr. Clark is now figuring. When this is applied to the large telescope, it converts it into a gigantic photographic camera.

The automatic records which this will give of the features of the moon, the planets, and the stars will unquestionably be far beyond what has been attained elsewhere. As it will be some months yet before this great photographic lens will enter into active work, I prefer, in this case also, to wait until results are actually attained before announcing what they are likely to be.

Californians may be sure that they have a magnificent observatory, splendidly equipped and complete in every essential respect. The Lick trustees, and especially Captain Floyd and his faithful coadjutor Mr. Fraser, have completed their task in an admirable manner, according to the matured and scientific plans.

A few improvements may be suggested by actual observation with the instruments, but nothing of material moment is now unprovided. The regents of the university have made provision for the support of the observatory in a liberal and wise manner, and are about to appoint a corps of observers, all of whom are highly competent and most of whom have already distinguished themselves in their chosen branch of science. The great gift of Mr. Lick to his fellow citizens is about to bear fruit, and I, for one, have no doubt as to the ultimate result.—*Edward S. Holden, in San Francisco Call.*

UNIVERSAL OPTICAL APPARATUS.

By V. L. ROSENBERG, of St. Petersburg.

IN the year 1877 I exhibited, at a *seance* of the St. Petersburg Physical Society, an apparatus which rendered visible the direction of beams of light, and it answered for exhibiting all the experiments of elementary optics, so that I named the instrument "universal optical apparatus." In its former arrangement, which was indeed an objectionable one, the optical effects were produced on a horizontal surface, which formed the bottom of a blackened box, which was only open on the side used by the spectator. With this arrangement only a limited number of people could follow the demonstration together. As source of light, I adopted petroleum lamps or candles. The apparatus here described is modified so that the optical effects are produced on a vertical plane and can be simultaneously exhibited to a large audience. The experiments can be produced either with weak lights (lamps, candles) or with sunlight, electrical or Drummond lights.

On the foot, A, is sustained the square upright, B, adjustable for height by means of the screw, S. To the upright the board, D, is attached at its center of gravity by a ball and socket joint, so that it can be twisted in all directions. The front face of this board is covered with dead white paper. The metallic plate, C, has, as shown in the figure, two slits, 1 and 2, that can be regulated by slides. Beneath them two petroleum lamps are attached to the upright, which are provided with special screens or opaque chimneys, not shown in the cut. The plane of the flame must pass through the slit. To the board, D, the square metallic rod, E, is attached parallel to its white face. Along this rod holders for cylindrical lenses, a prism, and a mirror can be distributed and secured by means of screws. In Fig. 1 the following is the order: Through the slit, 1,

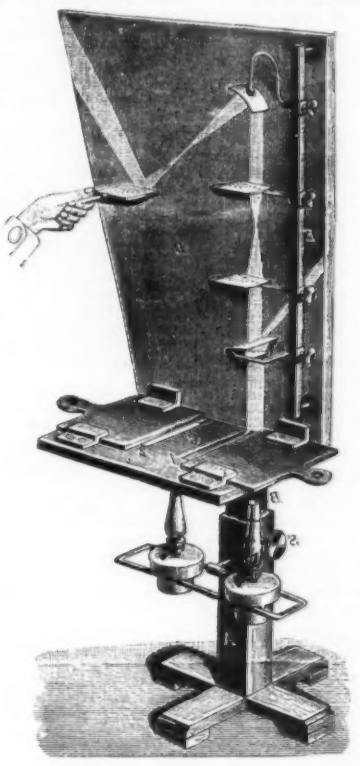


FIG. 1.

light falls upon the prism. One part is refracted, the other part goes on to the cylindrical condensing lens, and is brought to a focus. The diverging rays are then again brought into parallelism by the second cylindrical lens, by the obliquely placed cylindrical convex mirror, are a second time brought to a focus, and eventually are reflected by a plane mirror.

The course of the rays of light is sharply defined and therefore clearly visible. By using a flint glass prism a strong spectral band is obtained which, by means of the cylindrical glass, can be again brought back to a white beam. The first cylindrical lens collects the rays to a point which can be regarded as the origin of luminous rays. If we set up a second lens or the convex mirror at a correct distance, we will obtain an image of this luminous point, and can, by moving the first lens, cause the positions of the luminous point and of its image to vary, and can thus visibly produce the action of lenses or reflection by concave, plane, or convex mirriors.

In Fig. 2 is shown the appearance produced by individual thin beams of light. Under the plate, C, are

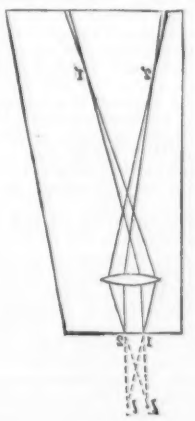


FIG. 2.

now placed two lamps, represented by the dark points *l l*, and the slits, 1 and 2, are brought close together. The slits are thus adjustable. Thus arranged each lamp throws two fine white rays upon the paper. As is seen in the picture, the points 1 and 2 can be regarded as the immediate source of the light rays, and their images 1 and 2′ are produced by a mirror or lens.

Without going any further, it is clear from what has been said that this apparatus provides for all necessary geometrical constructions for lenses, prisms, or mirrors. It also enables us to supply complicated representations of phenomena such as the path of rays of light in Figeau's and Foucault's experiments (estimation of the velocity of light), or in telescopes and microscopes. If we place colored glass over the slits or above the lamps, the light appears colored. Here I may remark that even when kerosene lamps are used as the sources of light, it is not completely darkened.

Fig. 3 shows a supplementary apparatus which can be used alone. On a board, A, covered with white paper is fastened a wooden disk, B, that can be rotated. To the center of this disk is attached a hollow half cylinder of glass, which can be filled with water through a stopped aperture. This auxiliary apparatus is placed with its own slotted base plate, C, on the plate, C, of the other apparatus (Fig. 1), so that the ray of light passing through the slit falls upon the center of the half cylinder, whose axis of rotation lies in the center of the plane face. If the plane face of the half cylinder is turned toward the slit, a rotation of the disk carrying it by means of the handle produces the illustration of the refraction of light on going from air into water. If, then, the cylindrical surface is turned toward the impinging ray of light, we can illustrate the passage of light from water into air, or else, according to the desire of the experimenter, total internal reflection may be produced. Angular divisions on the

FIG. 3.

rotating disk make possible more accurate measurement of all essential angles. If we attach to the plane face a suitable mirror with its reflecting face outward, which can be done by a rubber ring passed around the glass vessel, we can demonstrate the law of reflection. The half cylinder when only partly filled works as a prism with variable refracting angle. Without going further into all the peculiarities of the universal optical apparatus, it is clear from what has been said that it is capable of illustrating all the laws of elementary optics, because it makes the course of all light rays immediately visible, which the student must otherwise laboriously acquire from the tables.

If the board, D, is turned through an angle of 90°, and a magic lantern with electric or calcium light is placed before the slit in the plate, C, all the phenomena described can be produced with this more intense source of light in daylight in an undarkened auditorium. It is evident that sunlight can also be used.

The board, D, also can be brought into a horizontal plane, since it rotates on a universal joint. This is advantageous, because the cylindrical lens, mirror, and prism can be directly placed upon the white surface, so as to simplify greatly the work of the experimenter.—*Zeitschrift fur Instrumentenkunde.*

ELECTRIC ENERGY FROM CARBON WITHOUT HEAT.*

By WILLARD E. CASE.

THE following experiments, undertaken by the author, may be of interest as indicating the way in which the cheap generation of electrical energy may possibly be brought about.

In the first experiment, an element was formed through which heat energy was converted into electrical energy, in which the correlation of forces is beautifully illustrated.

It is a sort of voltaic battery, in which plates of tin and platinum forming the electrodes are immersed in a solution of chromic chloride, which has no action on the plates at ordinary temperature, as no current is generated. The cell is hermetically sealed, and when heated the liquid becomes active, and part of one of its elements, chlorine, leaves the chromic chloride, goes over and temporarily combines with the tin, forming a protochloride of tin. The chemical action generates an electric current, but soon the tin is all converted into chloride, and the current ceases. When the cell is cooled, this temporary combination of the chlorine and tin is broken up, and the chlorine returns to the chromium protochloride. The tin being set at liberty falls as a metallic precipitate to the bottom of the cell in the form of beautiful crystals, ready to renew the combination when the cell is again heated. None of the materials of the element are destroyed. They last an indefinite time. The chlorine changes from chromic chloride to tin and back, as often as the cell is heated and cooled.†

It is well known that the voltaic battery converts the potential energy of a metal directly into electricity, without heat. This cell, similar to the voltaic battery, converts heat into electricity. The voltaic battery acts at ordinary temperatures, giving up all the energy stored in the metal, and there is the end of it; while this cell acts only when heat is applied to it, converting part of this heat into electricity. After the tin has all been converted into chloride the cell becomes inert, no matter how much more heat be applied. The cell must then be cooled to get this tin back into the metallic state. So here it is necessary to have a difference of temperatures, the tin and liquid being simply a medium by which heat is transformed into electric energy.

It will probably be found that the solution of the tin absorbs heat, and so tends to cool the liquid, and the precipitation develops heat, and so tends to warm the liquid, and that the part where the solution occurs must be kept warmer than that where the tin precipitates. An investigation would probably show that when electric currents are generated the heat absorbed by the solution of the tin is in excess of that generated by the precipitation by the equivalent of the electrical energy developed, and that the possible excess is governed by the second law of thermo-dynamics. If the cell works between 80° and 180° F., the E. M. F. at the higher temperature is about 0·26 volt, the efficiency is less than 16 per cent., as the possible efficiency $= \frac{T - t}{T}$ reckoned from absolute zero, or $\frac{638° - 538°}{638°} = 0{\cdot}157$ per cent. In fact, this cell is a heat engine, analogous to the thermopile, which is said to convert only 2 per cent. of the energy of the coal into electric energy. In practice, probably nothing like 16 per cent. could be utilized.

It is an inexorable law of nature that under the conditions in which we live a great waste must accompany the transformation of heat into any other form of energy. In the condensing steam engine it requires to condense the steam four or five pounds of water to every pound of steam. Three-fourths the heat used goes to warm that water, and is wasted. In hot air engines or gas engines a cold water jacket must be used, and to it goes the larger share of the heat employed. In the thermopile one set of junctions must be kept cool by circulation of air or water. In Edison's pyromagnetic generator the iron tubes must be cooled by a blast of cold air.

By the second law of thermo-dynamics the minimum amount of heat that goes to this cooling agent is the fraction $\frac{t}{T}$ of the total amount employed, where t is the temperature of the cooler reckoned from the absolute zero and T the higher temperature of the working substance; t cannot be less than about 500°, so the numerator of the fraction is always large, and the heat wasted is the larger portion. Understand that this is the law of nature; it is inevitable under the conditions in which we live. No cunningly devised furnace, or feed water heater, or cut-off, or triple expansion apparatus, or pyro-generator can save this heat. The most that any of these devices can do is to save what would otherwise be wasted over and above the proportion $\frac{t}{T}$.

But are we to go on wasting all this energy of fuel? Cannot some means be employed to utilize it? We know that the voltaic battery is not a case of the transformation of heat into electrical energy; it produces electrical energy directly. The second law of thermodynamics does not apply, as no heat appears. If we could convert the chemical energy of coal and oxygen into electric energy, directly and cheaply, we would do away with all our steam motors at once. There is no known reason why a cheap substance may not be found which will act on coal and develop electric currents in place of heat. This electric energy would be the equivalent of the heat energy that would be developed by the combustion of the same coal in the ordinary way, and could be transformed into mechanical power, heat, light, etc., with small loss.

So far, little progress has been made in this direction. Some time ago, Jablochkoff produced a battery in which plates of carbon and iron were immersed in fused niter. The carbon being oxidized furnished strong currents. The objection to this element is the generation of heat through local action. To it the second law does not apply. Another battery of more interest than the first is an illustration of an element which is not affected by the second law, as heat is not essential to its operation, as the energy due to the complete oxidation of carbon is converted into electric energy directly.

In a glass cell containing suphuric acid, c. p. sp. gr. 1·81, temp. 75 Fah., two electrodes were immersed, one of platinum, the other of lump graphite; only a slight E. M. F. was indicated, 0.007 volt, due to the combination, the graphite acting as a positive element; on the addition of a small quantity of chlorate potassium to the acid the E. M. F. immediately rose to 0·08 volt, the graphite being disintegrated after a time. This cell polarized rapidly, which was partially prevented by mechanical means. The reaction of chlorate potassium with sulphuric acid may be represented by the following equation: $3\,KClO_3$ (chlorate of potassium) $+ 2H_2SO_4$ (sulphuric acid) $= 2\,ClO_2$ (peroxide of chlorine) $+ KClO_4$ (perchlorate potassium) $+ 2\,KHSO_4$ (acid sulphate of potassium) $+ H_2O$ (water).

A method of exclusion was adopted to ascertain the oxidant of this electrolyte; chlorine peroxide (ClO_2) appeared to be the only active agent. It is decomposed by the carbon, chlorine being evolved with some oxygen. It was assumed that in this cell graphic acid ($C_{11}H_4O_5$) was formed as the result of the chemical actions. There is probably much waste of energy through local action, as the chemical reactions go on when the circuit is open, but to a less extent. In another experiment an electrolyte was formed of sulphuric acid and chlorine peroxide, the gas being formed in a retort by the action of sulphuric acid on chlorate potassium, and conducted over into the acid in which it was dissolved. This cell, with a positive element of graphite, opposed to platinum, gave an E. M. F. of 0·7 volt.

A similar combination was used with a solution of chlorine peroxide in water as the electrolyte. The E. M. F. assigned to these cells is only approximate, as it was found dependent on the quantity of chlorine peroxide in solution, which was constantly changing. The resistance also varied with the different degrees of concentration of the exciting fluid.

Different forms of amorphous carbon were substituted in place of graphite in the first form of cell. Gas carbon gave an E. M. F. 0·007 volt when opposed to platinum in sulphuric acid. On the addition of chlorate potassium the E. M. F. rose to 0·5 volt.

Carbon, produced by the action of sulphuric acid on cane sugar, in this experiment gave an E. M. F. 0.3 volt.

The carbon of animal charcoal, wood charcoal, coke, and anthracite gave an E. M. F. variable with each form, ranging from 0·3 volt to 1·25 volt. The measurements of E. M. F. of the various combinations were made with the electrode immersed in separate parts of the same solution, that the concentration of the liquid and quantity of gas in solution might be as nearly equal in each cell as possible. It was found when the carbon in comminuted form was contained in a porous cup that the combination gave an E. M. F. of 1·24 volt, apparently due to the presence of the oxygen of the air.

It is impossible at the present stage of the investigation to assign any definite value of the E. M. F. to these forms of amorphous carbon. In some cases they appear to have an E. M. F. higher than that of graphite.

The energy of the combination of carbon and oxygen when completely oxidized to (CO_2) carbonic acid gas is stated to be 9624 foot pounds per grain equivalent, which is 2·0594 equivolts.* In these carbon elements the E. M. F. is not so high, as there must be deducted the counter E. M. F. or polarization, and the energy due to the force of setting chlorine free.

A resort to chemical analyses of the products formed by the reaction in the cell indicates the following conclusions:

First.—Carbons produced by the action of sulphuric acid on cane sugar proved to be partially oxidized, or impure carbon.

Analyses gave the following numbers:

C	62·20 per cent.
H	1·61 per cent.
O	36·19 per cent.

Analyses prove that ($H_2SO_4 + KClO_3$) sulphuric acid + chlorate of potassium oxidizes carbonaceous bodies, like the above product of (H_2SO_4) sulphuric acid on cane sugar, to CO_2, and further, that such bodies first are changed to compounds soluble in the acid (caramel-like substances), which are rapidly oxidized to CO_2.

Second.—Battery carbon of the composition:

C	96·20 per cent.
H_2O	0·70 "
Iron, etc.	2·30 "

The fact was shown that this form of carbon can be oxidized to CO_2.

Third.—Wood charcoal, of the following composition after ignition:

C	94·0 per cent.
H_2O	5·5 "
Siliceous res	0·5 "

This, after repeated reignition, was oxidized by the electrolyte to CO_2, no intermediate compounds being formed, and further, in case of pure amorphous carbon, the oxidation is complete; that is, that all the carbon is oxidized to CO_2.

These analyses were made with the solution at a temperature 122 F. to hasten the action, the carbon being in contact with the platinum. In these elements the oxidizing material is too expensive for practical use.

Undoubtedly the direction of experiments in the future will be to find some substance which will absorb oxygen from the air and give it up to the carbon; in fact, acting as a carrier of oxygen, so oxidizing it without heat; and this is not improbable, as we already know of substances which do this, though giving a low E. M. F., as, for instance, the ferric salts are reduced to ferrous by agitating their solutions with carbon, being regenerated by absorbing oxygen from the air.

By pursuing this line of investigation, we can be sure we are not ignorantly striving against any law of nature when attempting to convert the whole potential energy of carbon into electrical energy.

* Read before the American Institute of Electrical Engineers, Jan. 10, 1888.

† This cell has been described in *Proc. Roy. Soc.*, No. 244, 1886.

* See *Jour. Q. Chemical Soc.*, Vol. XII., October, 1859.

† Great care must be taken in the preparation of this gas, as it explodes at a temperature of about 140 F. It can be preserved in the dark, and is decomposed by sunlight into its component parts.

[NATURE.]

HUGHES' INDUCTION BALANCE.

HAVING just made a Hughes' induction balance, I have, in the course of some experiments with it, observed what was new to me, for I have not seen it mentioned it any account of the balance. I take the liberty, therefore, of asking through your columns whether the explanation resolves itself into the difference between paramagnetic and diamagnetic substances. The apertures of my bobbins are 1½ inch in diameter; my primary current is from three Daniell's, and the break is a bent steel spring whose free point just grazes the surface of a mercury cup, so that the merest touch with a finger causes a series of regular breaks. Now, if I place an iron or steel disk, or ring, such as a key ring, inside the aperture, the telephone sounds loudly if the plane of the disk or ring is at *right angles* to the plane of the coils; but very, very faintly if it is *parallel* to the plane of the coils. On the other hand, if a disk, or ring, or coil of wire, of any of the diamagnetic metals—copper, brass, zinc, silver, gold, aluminum, lead—be used, the telephone sounds loudly if the plane of the disk or ring be *parallel* to the plane of the coils; but very faintly, if at all, when it is perpendicular to the plane of the coils. Further, if a short *bar* of soft iron, or of nickel, be inserted so that the length of the bar is parallel to the plane of the coils, almost no sound is heard; but if it be turned through a right angle, so as to be perpendicular to the plane of the coils, the sound is a maximum. Have we in this simple instrument the ready means of distinguishing paramagnetic from diamagnetic substances?

J. COOK.

Central College, Bangalore, S. India, September 26.

To make children have pretty teeth, a French authority says begin with the second dentition to press back with the finger every morning the teeth which have a tendency to press forward, and to pull forward those which turn backward. As a wash, boil in a tumblerful of water a pinch of quassia wood with a pinch of pulverized cacao. It strengthens the gum and whitens the teeth. Wash the mouth after each meal with lukewarm boiled water.

* See Sprague's "Electricity," p. 519.

ELECTRICAL TELEPHONE BOXES.

AN interesting phase of the prolonged litigation between the American Bell Telephone Company and the American Cushman Telephone Company was developed on Sept. 17, 1887, near Chicago. In the gray dawn of the cool, crisp September morn, an aggregation of legal and expert electrical talent rarely seen outside a well appointed lawyer's office or the purlieus of a court room could have been observed taking ocular and oral evidence under most extraordinary circumstances. There was R. T. Roberts, of Boston, the keen legal representative of the Bell corporation; Professor Charles H. Cross, of Boston, whose name is known America over; Judge Smith, of Chicago, the active, clear-headed, and quick-acting attorney of the Cushman Company; Attorney West, of West & Bond, Chicago lawyers who attend to the Bell interests in this section; L. D. Parker, of Chicago, superintendent of the Postal Telegraph Company, and who is also interested in the Cushman telephone; Mr. Hotchkiss, secretary of the Cushman Company; L. O. McPherson, now with Professor Elisha Gray; and other experts. There were stenographers, too, with lightning pencils, ready to make record in case their services were needed.

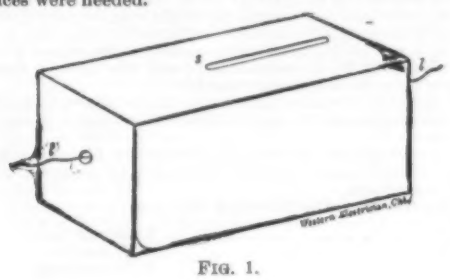


FIG. 1.

The purpose of the meeting at the unusual hour and place necessitates a preface of some length, and involves, to a limited degree, a narrative of Dr. Cushman's accidental discovery of his "talking boxes," concerning which much testimony has been taken at different times here and there for many months. This is the story told of the discovery:

Some time in 1852 Dr. Cushman constructed a telegraph line from Racine, Wis., across the country northwest. In those days considerable annoyance was experienced from lightning, which would burn out the magnet coils of the instruments. At that time this was more of a misfortune than it would be now, as they were then so far removed from a place where repairs could be made, and express companies did not make as prompt deliveries as they do now. The doctor concluded that it would be just the thing to catch the lightning by some means and carry it to the ground before it could get to the telegraph instruments and damage them. Therefore, by aid of blacksmiths, cobblers, and carpenters, he constructed that part of the box shown in the sketch, Fig 2, bearing the reference letters, *l*, *d*, *d*, *g* and *c*, which have meanings as follows: *l*, line wire; *d*, *d*, copper disks; *g*, ground wire; and *c*, a coil of fine wire inserted in the main wire and carried on to the instruments. This part of Fig. 2 was the doctor's improved lightning arrester, and in it telegraph men will recognize the familiar disk lightning arrester which is to this day used on telegraph switch boards, and electric light men will recognize the fusible safety catch used with every incandescent lamp in circuit. The doctor's idea was that when the lightning came in on the line, the difference of potential being so great, the discharge would jump from the disk connected with the main line to the disk in close proximity connected to the ground wire, and thence to the ground; but should it, or a portion of it, fail in this, it would burn the little coil of fine wire placed in the main circuit for the purpose, and thus open the circuit and save the register or relay magnets of the telegraph instruments from destruction. After placing these "boxes," as he called them, in circuit, the trouble from lightning ceased, but whether from a streak of luck, a mere coincidence, or whether the boxes were actually doing the work the doctor expected of them, was the question which greatly disturbed him. He, therefore, conceived a "machine" which he could add to the arrester and which would act as a tell-tale on the lightning. He put into the box a large horseshoe electro-magnet of soft iron, *h*, Fig. 2, and which for the

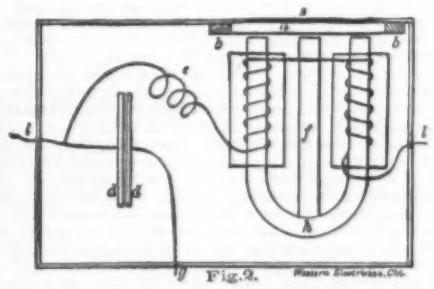


FIG. 2.

purposes of the trial noted below was made of 6"×¾" round iron. Connected to the horseshoe at the yoke or neutral point, he placed a steel magnet, *f*, Fig 2, its upper end being in line with the upper ends of the electro-magnet tines. The coils were included in the main line. Over these three magnets he placed a very thin piece of sheet iron, *a*, supported to the cover of the box by intermediate pieces of wood, *b*, *b*, almost, yet not quite, touching them. In this position the diaphragm remained until the coils became supercharged, as by lightning, when the diaphragm or strip of iron would be drawn down on to and in contact with the magnet and "freeze" to the permanent and electro-magnets. After the lightning had left for parts unknown, the diaphragm would remain in this position until removed by a severe pull or heavy jar. The diaphragm or strip of iron served as an armature to close the magnetic circuit, which, being supercharged by the lightning, so remained until the magnetic circuit became broken and the magnetic potential again reduced to normal. The permanent magnet assisted the electro-magnets and enabled them to retain the supercharges as described. When the strip of iron was found down tight on the magnet, the doctor knew that his arrester had done its work. Observations were made through the slot, *s*, Figs. 1 and 2. In theory and in construction this tell-tale of the doctor's lightning arrester was a telephone receiver, and it was found that this instrument, clumsy and rude as it was, actually transmitted sounds, and, as claimed, audible speech.

Dr. Cushman subsequently made with more pains other boxes exactly the same in principle as the first, but of better construction. One of these instruments is shown in the sketch, Fig. 3. He substituted for the horseshoe magnet the magnets of a register shown at *h* and *h'*, but the principle remained the same, and in both cases the coils were wound toward the left.

These "talking boxes" have been known in the evidence in the case as the "lightning arrester talking box" and the "register talking box." To rebut expert testimony that such boxes as had been described in

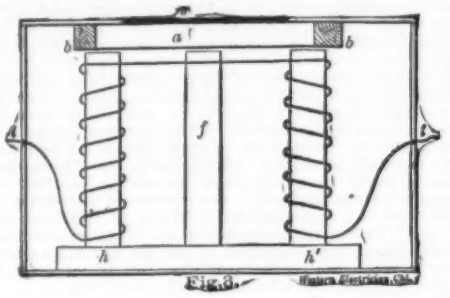


FIG. 3.

evidence could not transmit speech over a telegraph line six miles in length, the trial of September 17, 1887, was made. At a suburb of Chicago called Montrose, one of the boxes was stationed, and at a point between seven and eight miles distant the other box was placed. One of the boxes was of the lightning arrester style and the other box was of the register style. A wire of the Postal Telegraph Company was used, and perforce at a time—between five o'clock and half-past seven o'clock in the morning—when the test could be made without conflicting with the use of the wire for business. Furthermore, the place was chosen on account of its freedom from the noise of the city, and as well a freedom from induction from other wires. Questions were asked and answered from one point to the other, and conversation was carried on. The lack of means of adjustment in the crude instruments interfered to some extent with the success of the trial, but there seems no doubt that the attempt of the Cushman company to rebut the evidence that the boxes were incapable of transmitting speech was successful, and that the boxes would and did transmit speech.—*Western Electrician.*

SNOW HALL OF NATURAL HISTORY, AT LAWRENCE, KAN.

THE legislature of the State of Kansas, during its biennial session of the year 1885, appropriated fifty thousand dollars for the purpose of erecting a natural history building for the University of Kansas. The erection of such a building was rendered imperative by the extensive botanical, entomological, zoological, and geological collections brought together under the supervision of Prof. F. H. Snow, whose connection with the institution dates from its foundation in the year 1866. The building was completed in the autumn of 1886, and was formally named and dedicated to the purposes for which it was erected on Nov. 16 of that year. It has two principal stories, each sixteen feet in height, together with a basement and attic so commodious and well lighted as to make the structure practically four stories in height. The building from basement floor to attic roof is divided into two portions, partially separated from each other by the main entrance hall and stairways. The portion to the west of the entrance is devoted to the exhibition of the various cabinets, while the opposite portion is assigned to the work of instruction. The collections belonging to each department are upon the same floor with the laboratories of that department, easily accessible to both students and instructors. The arrangement of the various apartments is so well indicated in the accompanying plans as to require no verbal description. This arrangement was suggested by Mr. J. H. Emerton, of New Haven, Conn., who furnished the preliminary plans which formed the basis upon which the legislature was solicited to make the appropriation. Mr. Emerton's outlines were placed in the hands of Architect J. G. Haskell, of Topeka, Kan., who completed the architectural adaptations in the matters of construction, light, heat, ventilation, and exterior style, in a successful and satisfactory manner. The rooms most naturally grouped themselves so as to form a rectangular building; but, for the purpose of increasing the volume of light and also improving the architectural effect, their form was somewhat changed.

The building is most admirably lighted; the volume being so great that on a cloudy day the occupants of laboratories need not seek proximity to the windows for microscopical work, and the museum halls may have cases arranged in any desired relation. The large museum rooms are lighted on three sides, and necessarily have one side not lighted. To prevent this from being a dark side, a plate glass window, eight feet wide and eleven feet high, opposite the center of the unlighted wall, was added to the ordinary means of lighting, and has the effect of giving uniformity of volume throughout the entire space.

The exterior is in the Romanesque style, with rock-face ashlar and cut stone dressings, the stone being from the well known Cottonwood quarries of Kansas. The main approach is by a broad flight of buttressed stone steps under a handsomely decorated portico, the decorations being suggestive of the uses of the building. Numerous stone panels are provided about the building, which may, if desired, be utilized for illustrations of natural history subjects cut in bass relief.

The construction of the building is nearly fire-proof. All bearing girders are of iron, and all floors are deadened with mortar on corrugated iron laid between the joists. All partitions are non-combustible, all lathing is of wire cloth, the roof is covered with slate and dressed with iron cornices, ridge and hip rolls. All interior finish is polished hard wood, so that little material is presented to feed combustion.

Heating is by steam, the "indirect" method being employed to furnish the rooms with warm fresh air, and the "direct" method for securing proper temperature.

Fresh air is introduced into the building by means of a "plenum" extending under the entire building, and connecting with the outer air by arched openings and areas. Ventilation is accomplished by means of large flues leading from near floor and ceiling of all rooms to a large iron chamber in the attic, in which sufficient radiation is located to insure a successful movement of the foul air through a ventilating cupola to the exterior.

The construction of the building was by contract with McFarland & Son, of Lawrence, and completion was accomplished within the prescribed appropriation, and without "extras."

We are indebted to *Science* for our illustrations and the above particulars.

PREPARATION OF NITROGEN AND ANALYSIS OF AIR BY NITRIC OXIDE.

By T. O'CONOR SLOANE, Ph.D.

IF nitric oxide, which is a colorless gas, is brought in contact with oxygen, it becomes oxidized to higher oxides, principally to NO_2, producing brown gases. If the operation is conducted in the presence of water, the brown gases are absorbed by it, with production of nitric acid. If exactly the proper quantity of nitric oxide be added to atmospheric air, in a receiver over water, it will combine with all the oxygen, and, converting it into nitric acid, will leave the residual nitrogen in the receiver. It is one of the easiest, quickest, and safest methods of procuring nitrogen gas for lecture purposes, and affords an extremely instructive example of a calculation in stoichiometry. We may assume that on adding the gas to oxygen it is all oxidized to nitrogen dioxide (sometimes called tetroxide) NO_2. The reaction is thus expressed:

(1) $$NO+O=NO_2.$$

Then, on acting on NO_2 with water, the following reaction takes place:

(2) $$6NO_2+2H_2O=4HNO_3+2NO.$$

If we combine these equations so as to express the whole operation in one step, we may assume:

(3) $$6NO+6O+2H_2O=4HNO_3+2NO.$$

This tells us that, if six volumes of nitric oxide act upon three volumes of oxygen in the presence of water, the oxygen will disappear, and that two volumes of nitric oxide will be left over. But if there was an excess of oxygen present, the two volumes of nitric oxide left over in the reaction will combine with their due quantity of oxygen just as before, and the reaction will be repeated indefinitely until theoretically only two molecules of nitric oxide will remain. If, therefore, we start with one volume of nitric oxide gas and an indefinite quantity of oxygen, it will combine with a volume of oxygen represented by the following series:

$$\tfrac{1}{2}+(\tfrac{1}{2}\times\tfrac{1}{5})+(\tfrac{1}{2}\times\tfrac{1}{5}\times\tfrac{1}{5}),\ \text{etc.}$$

In other words, a geometrical series whose first term is ½, whose ratio is ⅕, and whose number of terms is infinity. Calling the first term a and the ratio r, the sum of such a series is expressed by

$$\frac{a}{1-r}\ \text{or}\ \frac{\frac{1}{2}}{\frac{4}{5}}=\tfrac{5}{8},$$

or one volume of nitric oxide gas will dispose of ⅝ of a volume of oxygen gas, or 1¼ volumes of nitric oxide will dispose of 1 volume of oxygen.

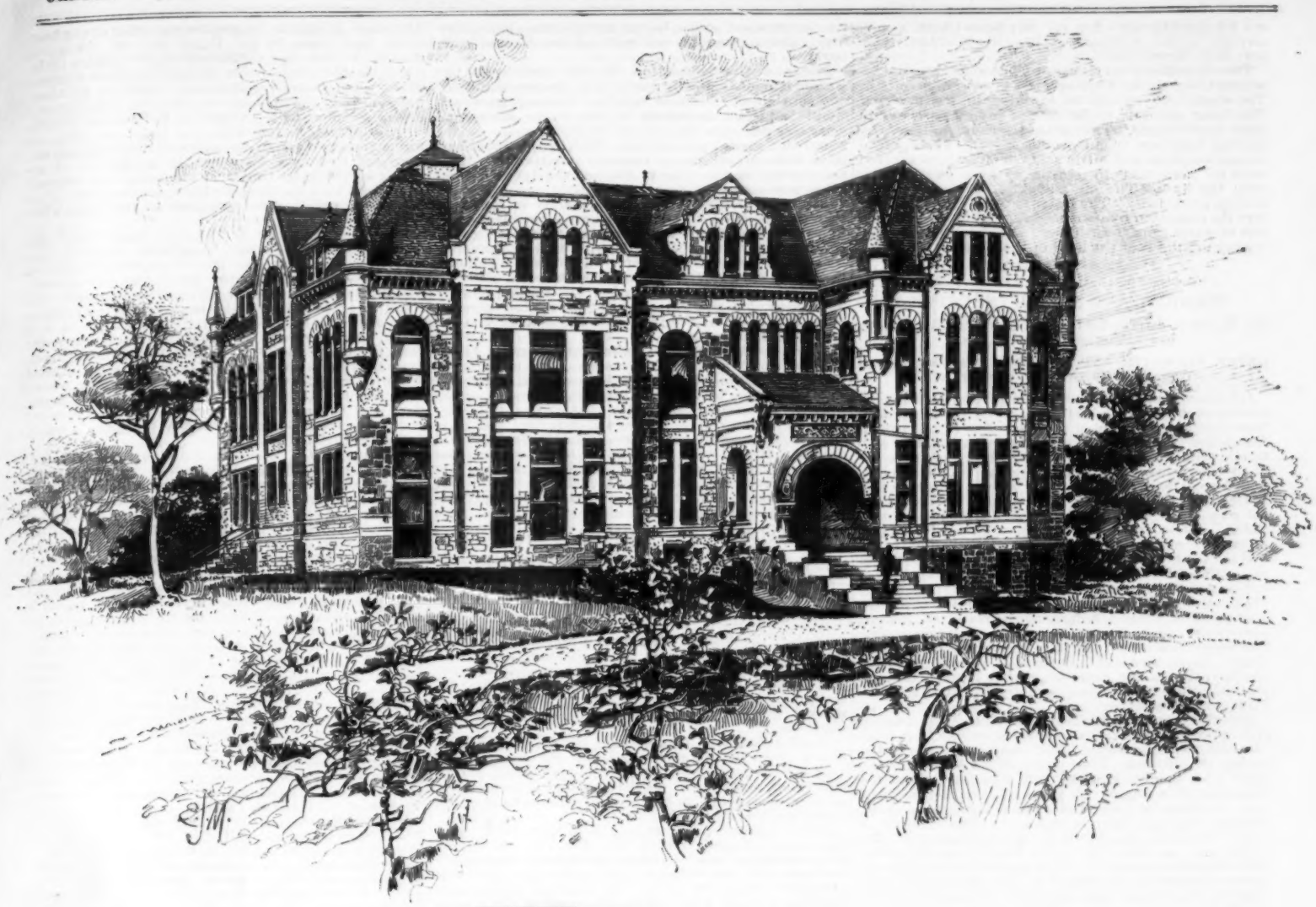
Now, suppose the experimenter wishes to make nitrogen gas from the air. Air by volume contains 20·80 per cent. of oxygen. A given volume, say 100 cubic centimeters, of air is inclosed in an inverted receiver over water in a hydraulic trough. To this is added a volume of nitric oxide equal to 1¼ times the oxygen contained, or 27·7 c. c. The brown coloration at once appears. The mixture at first rapidly and then more slowly shrinks, and eventually the residual nitrogen of the air, 79·2, will be left almost completely pure. Five minutes is generally enough to complete the reaction. It is better to add a slight excess of nitric oxide, say thirty per cent. in volume. As it is soluble in water, the excess slowly dissolves, leaving almost pure nitrogen. If the exact proportion only is used, there is danger that some will dissolve in the water unchanged before it reacts upon the oxygen of the air.

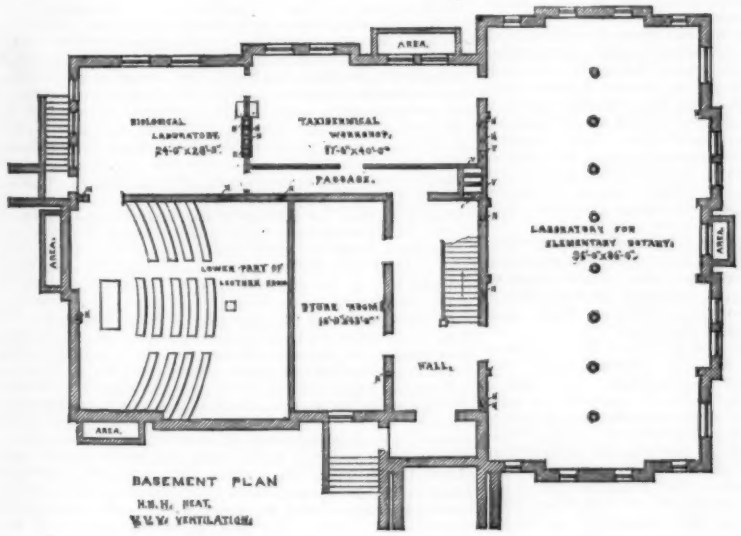
To analyze the atmosphere, the following method may be adopted: To a measured volume of air contained in a graduated tube a good excess of nitric oxide is added. The nitric oxide need not be measured provided it is in excess. The brown gases appear and are absorbed, and after five minutes' standing a reading is taken, and immediately a sufficient excess of air is introduced into the graduated tube. After five minutes a second reading is taken, and this gives the data for calculating the analysis. Thus the first reading gave the air taken. An excess of nitric oxide was added. This removed all the oxygen as nitric acid, which, with some of the nitric oxide, dissolved in the water. The second reading indicated, therefore, nitrogen and an unknown quantity of nitric oxide. A measured excess of air was introduced, and the last reading indicated the loss of volume due to the conversion of the residual nitric oxide combining with the oxygen of the air into nitric acid. Of this shrinkage ⅗ was due to nitric oxide. This quantity subtracted from the third reading gives the nitrogen present.

The following figures were obtained in a rapid analysis with the most primitive apparatus, simply a graduated cylinder and some test tubes. The operations were conducted over water.

1.	Air taken	78·0 c. c.
2.	Nitric oxide added	31·0 "
3.	Reading after standing	63·5 "
4.	Air added	31·0 "
5.	Final reading	92·0 "

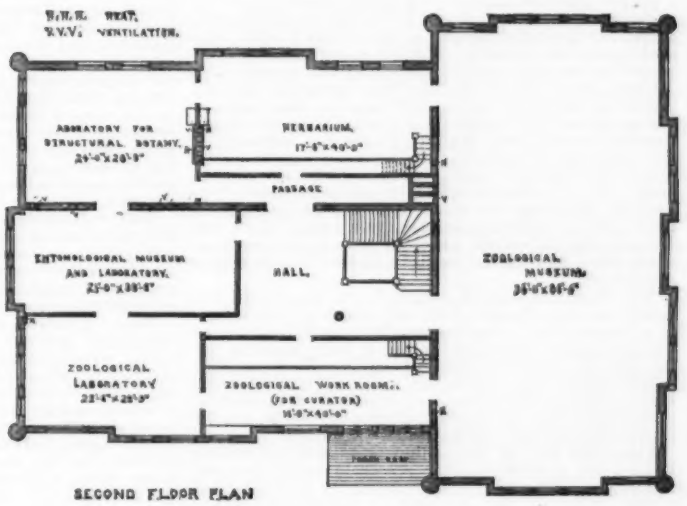
Calculation.—(*a*.) 63·5+31·0=94·5. (*b*.) 94·5—92·0=2·5.



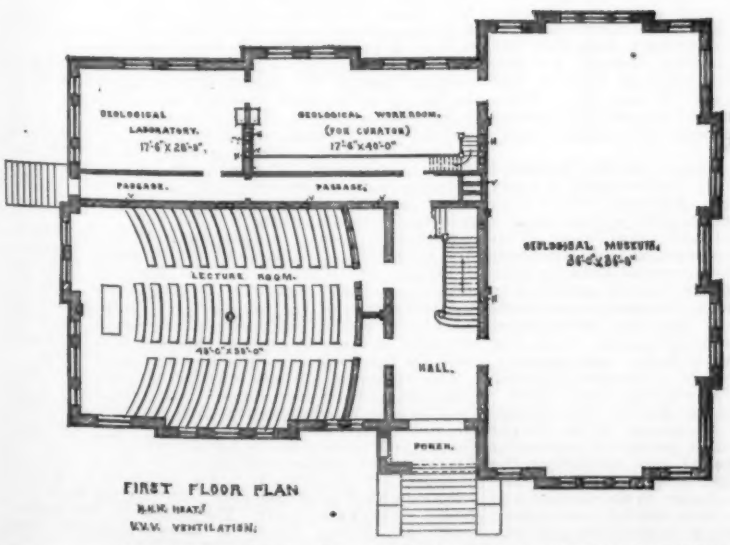


BASEMENT PLAN

H.H.H. HEAT.
V.V.V. VENTILATION.

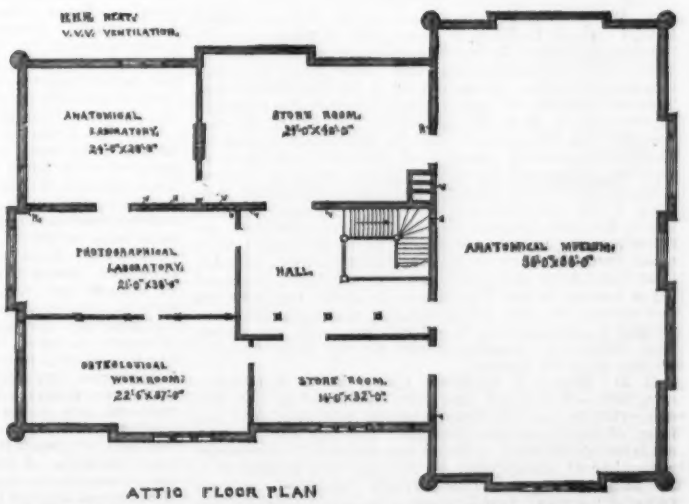

H.H.H. HEAT.
V.V.V. VENTILATION.
ARBORATORY FOR STRUCTURAL BOTANY. 24'-0" X 28'-0"
HERBARIUM. 17'-6" X 40'-0"
PASSAGE.
ENTOMOLOGICAL MUSEUM AND LABORATORY. 25'-0" X 38'-6"
HALL.
ZOOLOGICAL MUSEUM. 35'-0" X 85'-0"
ZOOLOGICAL LABORATORY. 22'-6" X 28'-0"
ZOOLOGICAL WORK ROOM. (FOR CURATOR) 16'-0" X 40'-0"

SECOND FLOOR PLAN



FIRST FLOOR PLAN

H.H.H. HEAT.
V.V.V. VENTILATION.


H.H.H. HEAT.
V.V.V. VENTILATION.
ANATOMICAL LABORATORY. 24'-0" X 28'-0"
STORE ROOM. 25'-0" X 40'-0"
PHOTOGRAPHICAL LABORATORY. 25'-0" X 38'-0"
HALL.
ANATOMICAL MUSEUM. 35'-0" X 85'-0"
OSTEOLOGICAL WORK ROOM. 22'-6" X 67'-0"
STORE ROOM. 16'-0" X 32'-0"

ATTIC FLOOR PLAN

SNOW HALL OF NATURAL HISTORY.—MR. J. G. HASKELL, TOPEKA, KAN., ARCHITECT.

(*c*) 2·5×⅘=1·43, say 1·5 c. c. (*d*) 63·5—1·5=62 c. c.= nitrogen in 78 c. c. of air. (*e*.) 62×100÷78=79·5%. Theory, 79·2. Error, 0·3%.

This furnishes a very elegant method of rapidly demonstrating to an audience the composition of air. The whole analysis can be executed in ten minutes. The great point is to be sure of having pure air and pure nitric oxide. The latter is easily prepared by heating together, in an evolution flask, a solution of ferrous sulphate and nitric acid. The first gas evolved must be permitted to escape so as to expel all air from the flask. The air added in (4) may be measured in a test tube. The latter may be graduated before the operation by pouring into it 30 cubic centimeters of water from the cylinder. A rubber band is then sprung around it at the level of the water.

[Continued from SUPPLEMENT, No. 628, p. 10035.]

CHEMICAL AND ALLIED INDUSTRIES.*

By WATSON SMITH, Lecturer in Chemical Technology in the Victoria University, etc.

GROUP VII.—DYES AND COLORING MATTERS FROM OTHER SOURCES THAN COAL TAR.

OF coloring matters or other principles, the chemical constitution of which is still unknown to us, we have those contained in most of the dyewoods, *e. g.*, logwood, fustic, quercitron bark, Persian berries, etc., and also tannic acid. (See Stand No. 796.) Many of these are of the very greatest importance to the textile colorist, and hence recourse must still be had to nature's resources. It is interesting to note that nearly all the coloring matters above referred to are such as require the aid of mordants in order to develop and fix upon fabrics the colors they are capable of producing.

Millward & Cryer, 10 Greenwood Street, Manchester (No. 795).—The exhibit of this firm includes samples of indigo and the model of an indigo factory; specimens of the seed, plant, etc., and classified samples of indigo; specimens of refined indigo, and extract of indigo; patterns of fabrics dyed with indigo. Indigo is a coloring matter used as a dyestuff in India from the earliest times. Cloth dyed with indigo has been found in the old Egyptian tombs, and the process of preparing and manipulating the dye is accurately described by both Pliny and Dioscorides.

The chief source of East Indian indigo is the *Indigofera tinctoria*, an herbaceous plant raised from seed, of which a sample is exhibited, which is sown in either spring or autumn. The plant grows with a single stalk to a height of about 3 ft. 6 in., and about the thickness of a finger. It is usually cut for the first time in June or July, and a second, or even a third, cutting obtained later in the year. The number of leaves which the plant puts forth determines the value of the crop, as it is in the leaves that the coloring principle is chiefly contained. The crude mode of manufacture carried on in Bengal at the present day coincides exactly with the description of the processes given by Pliny and Dioscorides. When the leaves arrive at a proper degree of maturity the plants must be speedily gathered, and each cutting rapidly executed during the night, for the scorching sun would wither the branches and injure the produce. A great many hands are employed in the gathering process, and the surrounding villages are all requisitioned. The workmen are dispersed in the fields at midnight, and in the morning the produce of the harvest is deposited in stone troughs previously filled with water. Under the influence of the sun's rays fermentation soon takes place, and after about 48 hours the liquid is drawn off into shallow vats. Here it is beaten about by means of oars by the natives, who enter the vats, the object being to expose the liquid as much as possible to the action of the air. During this process the greenish yellow fermented extract from the leaves assumes a deep blue or almost black color.

The liquid is allowed to stand, and the indigo blue which has been formed gradually settles to the bottom as a fine powder. The supernatant liquid is drawn off and the indigo precipitate is boiled with water in metal vats in order to prevent further fermentation, which would injure the indigo itself. The indigo paste is then drained in filters, and the dark blue clay-like mass is cut into cubes, dried in open air sheds, packed into chests, and sent to the Calcutta market.

The fresh leaf of the indigo plant does not contain indigo, but a color-yielding principle called *indican*. Under the influence of the fermentation and the subsequent oxidation this colorless or faintly colored and soluble indican is decomposed or split up into glucose and indigo blue. The former remains dissolved in the liquid, while the latter, being insoluble, is precipitated in the beating or oxidation vats as described. From Allahabad eastward vast districts are to be found in which this forms almost the sole product manufactured. Oude, Tirhoot, Upper Behar, and a large area of Bengal are almost entirely in the hands of the indigo planters. The average annual production of East Indian indigo during the last 18 years may be placed at 120,000 maunds (about 74 lb. to the factory maund), and the value over two millions sterling. The price of indigo has ranged within the same period, for fine Bengal and Tirhoot, from 8s 6d. per lb. in 1870, when the crop was 92,000 maunds, to 5s. 3d. per lb. in 1878, when the crop reached 155,000 maunds, and is largely governed by the abundance or paucity of the crop, which in its turn is influenced by the monsoon or rainy season. Although the main supply of indigo is furnished from East India (consisting of Bengal, Tirhoot, Benares, Oude, Kurpah, Madras, and Bimlipatam qualities), yet there are also some considerable imports from Guatemala, from Caracas in South America, and, in addition, from Java and some little from Manila, the capital of Luzon, in the Philippine Islands; but all these last named occupy relatively a subordinate position. Recent experiments by R. C. Phillips have also shown that indigo can be easily grown on the West Coast of Africa, near the Congo.

E. D. Milnes & Brother, Lumn Mills, Lancashire (No. 796).—The main products exhibited by this firm are extracts used in dyeing, calico printing, and tanning, of their own manufacture; also the raw materials from which such extracts are prepared: moreover, a number of chemicals and dry-salteries employed in the same industries. The extracts exhibited comprise those of logwood, fustic, quercitron bark, Persian berries, sapanwood, sumac leaves, myrabolams, galls, dividivi, valonia, chestnut, oak bark, quebracho, and larch bark.

The annual consumption of these articles in the United Kingdom already amounts to thousands of tons, and continues to increase rapidly. These extracts are simply aqueous decoctions of the above mentioned vegetable products evaporated to the requisite consistency with special precautions. They are now obtained in a state of excellence formerly unattainable, and promise ere long to entirely displace the dyewoods and other raw materials from which they are prepared. The improvements effected consist mainly in the adoption of improved mechanical means for insuring a thoroughly complete extraction of all valuable ingredients, and prevention of any deterioration or composition during both extraction and evaporation. This end is accomplished by the use of vacuum pans, in which the extraction can be effected at lower temperatures. Specimens of cloth dyed and printed with the extracts, etc., are shown in the same case, as well as fine examples of dyewoods.

Bourgeois Aîné, Rue de Caire, Paris; agent, Alfred Hallam, Post Office, Peel Causeway, Altrincham (No. 798).—The exhibit of this firm is composed chiefly of superfine colors for designers and engravers to calico printers. The colors are made up in five forms, viz., in tube, baton, flake, paste, and powder, and it is claimed for them that they are especially brilliant and opaque, and will work one over the other without loss of tone. These are the colors used in France in the production of the calico print designs, etc., so well known in this district. A selection of drawing materials as used by designers is also shown.

GROUP IV.—LAKES, PIGMENTS, PAINTS AND VARNISHES.

Rawlins & Son, Brook Works, Rainhill, Prescot (No. 753).—A fine exhibit, comprising the raw materials used in the manufacture of ultramarine, ultramarine in its intermediate stages, known as "raw ultramarine," "settled ultramarine," and "dried pulp ultramarine;" the finished ultramarine, and various manufactured goods illustrating its application in various industries; the raw materials used in the manufacture of "smalts," the fused cobalt glass or smalts in the intermediate stage, and the finished article ready for the market, together with manufactured goods illustrating its use.

Charles Scheu, 2 Cumberland Street, Manchester, and 65 West Regent Street, Glasgow (No. 754), exhibits very fine specimens of ultramarine colors, blue, green, and violet, and the raw material used in their preparation; also a model of the form of furnace used in the ultramarine manufacture.

Robert Ingham Clark & Co., West Ham Abbey, and Leadenhall House, London, E.C. (No. 775).—A variety of varnishes for coach builders, decorators, heald manufacturers, etc., also carriage spokes, panels, and healds coated with these varnishes. An interesting collection is shown of fossil gums and resins used in the manufacture of varnishes, including gum amber from the shores of the Baltic, gum mastic from the island of Chois, gum kauri from New Zealand, gum animi from Zanzibar and Demerara, also gums from the interior of Africa, *e. g.*, Angola, Benguela, Sierra Leone, and red Angola copals, also gum copal from South America. Among these specimens are two which merit special notice, *i. e.*, a mass of gum kauri from New Zealand weighing about 200 lb., and a mass of animi from Demerara containing embedded in its midst a large number of ants and other insects. Both these pieces of gum are said to be the largest of their kind yet discovered.

William Pakeman, Manchester Road, Stockport (No. 756).—Specimens of mineral and vegetable pigment colors for the use of calico printers; also bronze powders and colors for paper stainers, printers, and manufacturers, all guaranteed free from arsenic; lakes and mineral colors for lithographic inks, etc.

Henry Crookes, A.R.S.M., M.S.T.E., 4 Westminster Chambers, London, S.W. (No. 757), shows a heat-indicating paint and some of its applications. The paint, which is a specially prepared iodide of mercury, or contains that substance, takes its name from the property it has of changing color when heated to a certain temperature. The point at which the change takes place can be varied between 140° and 170° F. by certain modifications in the manufacture. Its principal use is to show when bearings of machinery or other surfaces liable to become overheated have reached a temperature which may be a source of danger. At such a point the paint changes its color from a bright red to a dark chocolate. When allowed to cool, it resumes its red color, and this change takes place whenever the paint is heated and cooled. As examples of its application two flatirons are exhibited, one painted a bright red, showing the color of the paint at a low temperature, the other painted dark brown, *i. e.*, the color which the paint assumes when the temperature rises over 150° Fahrenheit. Another application claimed for this paint is that it can be used for painting coils of wire through which electric currents have to pass. When the current exceeds a certain limit, the coil will become heated and the paint will change color, thus indicating the rise of temperature.

Jos. B. Freeman & Co., Grove Works, Lombard Road, Battersea, London (No. 758), exhibit a kiosk painted with their patent non-poisonous white lead, also samples of the lead, and boards painted with it and subjected to the action of sulphurous fumes. This non-poisonous white lead consists mainly of zinc oxide and lead sulphate, specially prepared from metallic lead, mixed together, and finely ground under great pressure. Many attempts had previously been made to utilize lead sulphate as a pigment, but without success, the product being quite useless, possessing neither the necessary density, body, nor opacity. Moreover, a large quantity of oil is required in grinding it, and as a paint it is what painters term "slimy," and works very badly under the brush. The difficulties were finally overcome by adding about 25 per cent. of zinc oxide (in itself a substance possessing neither good body nor density), and subjecting the mixture to great friction and pressure under heavy edge runners. A complete change in the character of the substances employed is thus effected, such indeed as it would appear impossible to produce by any mere process of mixing, and a pigment possessing great density, opacity, and whiteness is the result. The whiteness is said to be greater than that of the finest white lead made by the Dutch process. As regards density, 3 cubic feet of lead sulphate weighing 170 lb. per cubic foot and 1 cubic foot of zinc oxide weighing 58 lb., when mixed together and treated by the above process, yield the pigment in question, weighing over 200 lb. per cubic foot. According to Professor Church, when surfaces coated with this paint are submitted for various periods to the action of air containing sulphureted hydrogen, they remain unaffected, or are "only very slightly tinged;" when they are excluded from light for some time, the paint does not turn yellow or buff—a well known objection to the use of white lead.

Donald Macpherson & Co., Manchester Paint and Color Works, Knott Mill, Manchester, and 106 Cannon Street, London (No. 761).—The articles exhibited are a kiosk illustrating the use of Foochow enamels, metallic paints for exterior, quick-drying enamels, that require no stoving, and vases, bricks, and timber enameled with the quick-drying Chinese enamels with which tea trays and papier mache articles imported from China are coated. The paints have on drying an extremely hard, tough, glossy surface, are not affected by sulphureted hydrogen, and will not crack, blister, or scale off. They are suitable for machinists, japanners, and other manufacturers who have to turn out goods as soon as finished, and yet require a highly enameled surface.

Goadsby & Co.; office, 2, 4, and 6 Albert Bridge; works, Newton Heath, Manchester (No. 762), exhibit colors, paints, varnishes, etc., among which are a concentrated oil drier, used by linseed oil boilers and manufacturers of tarpaulin, oil cloth, and linoleum. It is said that one part of this drier to twenty parts of linseed oil makes it dry hard in about eight to twelve hours. Terebene is used by painters, decorators, etc., as a drier. Engine green is used for locomotive and other engines. It is stated that this paint does not change color or crack even when heated by means of superheated steam. Vermilionette is a substitute for vermilion, largely used at a time when genuine vermilion was high in price. It is a chromate of lead prepared in a special manner. A large number of prepared lakes of eosin are also called vermilionette by some makers, but though a good imitation in point of color, they do not stand exposure. This color is used by railway companies, manufacturers of printing inks, agricultural implements, etc. Goadsby & Co.'s paint detergent is used for washing down and cleaning off old paint and grease, and for washing lithographic stones and type. Varnish enamel paint, a combined color and varnish, household paint ready for use, and peroxide of iron paint are also shown.

Griffiths Brothers & Co., 6 Dashwood House, 9 New Broad Street, London, E. C. (No. 763).—The exhibits of this firm comprise aquol, a washable water paint; vitros bath enamel, for enameling baths, etc, without stoving; and Griffith's patent zinc white (sulphide of zinc). It is claimed for this latter article that besides being non-poisonous "it covers one-third more than white lead and 100 per cent. more than zinc oxide." It is said to have no chemical action upon metals, is not discolored by foul gases or bilge water, and is fire proof and unaffected by a red heat. It is also said that the most delicate tints or "tones" can be produced with it not possible with lead. This zinc white is produced as follows: Either zinc chloride or sulphate is precipitated by a soluble sulphide—sodium, calcium, and barium sulphides all having been used for the purpose—and precautions are taken lest any iron that may be contained in small quantities as an impurity in the zinc solution should be precipitated with the sulphide of zinc. The precipitate, being collected and dried, is calcined in a furnace, then raked out, while quite hot, into vats of cold water, when it is levigated and dried. An analysis by Dr. T. L. Phipson shows that the pigment consists of an oxysulphide of zinc. Pyrodene is a fire proof paint for fire-proofing wood, canvas, etc. It may be mentioned that all the timber work of the fine arts section of the exhibition has been treated with Griffith's pyrodene and painted with aquol.

F. & C. Osler, Birmingham and London (No. 768A).—This firm shows an ornate glass fountain, playing, according to a device of Mr. I. Levinstein, fluorescent water, *i. e.*, a faintly alkaline solution of fluorescein. The basin is painted with black and white bands, and shows the fluorescence remarkably well, the water appearing yellow by reason of the light transmitted from the white bands, and sea green when the black bands absorb the light. The non-poisonous nature of the fluorescein is illustrated by the fact that gold fish have been living in the water for two months.

GROUP V.—BLEACHED AND COLORED FIBER.

Ermen & Roby, Nassau Mills, Patricroft, and 14 College Land, Manchester (No. 771).—This exhibit of cotton yarns is divided into three groups: 1, mending, knitting, embroidery, and crotchet cottons; 2, polished cotton; 3, sewing cotton on spools and in balls.

1. The mending and knitting cotton being principally used for hosiery, it is important that the colors should be fast, so as to resist washing and exposure to the light. Consequently, the most permanent dyes are selected for these yarns, such as turkey reds, indigo blues, aniline blacks, etc. A large quantity of bleached knitting cotton is used. The same remarks apply in great measure to the embroidery and crochet cottons. The colors are made as fast as possible. Crochet cottons are principally used in white.

2. Godfrey Ermen, late partner in this firm, was the first inventor and patentee of the process of polishing or glazing cotton thread, and the firm has made this article a specialty ever since. Polished thread is shown, wound on reels of various sizes. The aim of the firm has always been to combine elasticity and softness with strength, in order to produce the most suitable thread both for the sewing machine and for hand sewing.

This exhibit as a whole is rendered something more than striking—in fact, almost magnificent—by being itself incorporated in another representation. In short, the items above given are incorporated in a model of the famous monument at Athens erected B. C. 335 by Lysikrates to celebrate his victory for the best chorus at a dramatic contest. It takes the form of a small temple in the Corinthian style, showing the finest and purest style of Greek art. The height of the original is 35 feet, Messrs. Ermen & Roby's facsimile being 18½ feet.

Ch. Weber & Co., Thann, Alsace (778).—The exhibit

* Report on Section III. of the Manchester Royal Jubilee Exhibition.

of this firm consists of cotton yarns, slubbings, rovings, etc., both dyed and bleached, in the cop, spools, and bobbins. The process of dyeing and bleaching the yarn in this form is worked on the Continent, and as it dispenses with the operation of reeling, pirn winding, etc., effects economy in space, plant, time, and labor. It is also claimed that when yarns are dyed in this form there is less waste and no shrinkage or loss in length.

Select exhibit of committee of Section III., collected by J. J. Hummel, Yorkshire College (No. 779).—A most valuable and instructive exhibit, collected and arranged with very great skill and considerable artistic effect. Messrs E. Potter & Co., we are informed, supplied much of this valuable exhibit of calico prints, and placed their whole collection at Professor Hummel's disposal. Messrs. F. W. Grafton also contributed liberally. An illustration of the gradual advance in artistic design and coloring since 1785 to the present day is shown, the equal of which has rarely been seen and probably does not exist outside that belonging to the Societie Industrielle de Mulhouse. A series of woolen patterns dyed with the natural coloring matters, and also with the artificial (coal tar) coloring matters, is shown, also compound shades, dyed with mixtures of three coloring matters, of each class. Besides these, patterns of cotton and silk dyed with coal tar colors obtained by Goppelsroeder's electrical method, and the apparatus by which aniline black is produced on cotton, and discharge white on indigo blue, by the aid of electricity.

William M'Farlane, Miller's Brook Dye Works, Heywood, near Manchester (No. 780).—This firm exhibits specimens of dyed cotton yarns used in the manufacture of colored textiles at home and abroad, *e. g.*, for dhootie, khakee, drill, and general trade, also specimens of dyed cotton, lace and lace yarns. The yarn is dyed in various forms—in hanks or bundles and in ball warps and chains. A special feature in this exhibit is the alizarin red dyed on yarn in the form of ball warp and chain. Until recently all yarn was dyed in the form of hanks, and the operations were almost entirely manual. The introduction of improved machinery, however, has made it possible to dye yarn in the form of ball warps and chains, and this method forms now a most important branch of the cotton yarn dyeing industry.

Select exhibit of committee of Section III., collected by Watson Smith (No. 781).

1. A series of silks dyed with coal tar colors in all the prismatic shades, according to a graduated system. These specimens were dyed by the eminent French firm, Marnas, Bonnet et Fils.

2. A set of specimens of fabrics printed and dyed in indophenol by the firm of H. Koechlin, of Lorrach, Alsace, as well as the indophenol white and blue in paste and powder. This dye was formerly proposed as a substitute for indigo, but its non-resistance to acids is much against it. Specimens of all the raw materials used in the preparation of the indophenol blue are shown, as prepared by Dr. Otto N. Witt.

3. A specimen of murexide, a crimson coloring matter, formerly prepared from guano, is exhibited, as originally manufactured by the late Robert Rumney, of Manchester, who first introduced the coloring matter into England. The discovery of magenta quickly crushed any hope of extending the use of this fugitive, but beautiful red. A piece of cotton cloth printed with murexide is exposed, and though full and bright when first placed in the case, is now much faded.

4. Piece of calico printed with alizarin on different mordants, the alizarin used being a 20 per cent. paste prepared from anthracene, made in South Russia from Baku petroleum residuum, by passing through red hot pipes filled with charcoal or coke. (See exhibit No. 733, Messrs. Ragosine & Co.) Specimens of the residuum and of the alizarin paste are also shown.

5. One pound each of the several kinds of coal used in the Manchester gas works for the mixture adopted in charging the gas retorts is shown, and by the side of these specimens a particolored strip of cloth dyed with the exact amounts of the coal tar colors that could be prepared from the products of the tar from one pound of such coal. The dyed strip of cloth thus strikingly represents the amount of coloring power in one pound of Lancashire gas coal

6. Watson Smith exhibits chemically pure specimens of the aromatic hydrocarbon series, and of phenols contained in coal tar.

7. The amount of bisulphide of carbon formed in coal gas making varies directly with the temperature of distillation adopted, and hence where, as in London, coal is dear and the gas supply required very large, the highest temperatures are employed. A maximum of carbon bisulphide will of necessity be formed in such cases and appear in the tar. Watson Smith, by fractionally distilling a quantity of rectified benzine, obtained from the "first runnings" of London coal tar, succeeded in separating no less than six per cent. of pure bisulphide of carbon. A specimen of this bisulphide is exhibited, together with the original benzine from which it was isolated. A small specimen of chemically pure benzine prepared by passing phenol over red hot iron borings is shown. Even ordinary alcohol is contained in some specimens of London rectified benzines, formed by the action of the sulphuric acid used in the purification, on a certain quantity of olefiant gas dissolved in the crude benzine and the subsequent action of steam in the final distillation process. A specimen of such alcohol, separated by Dr. Otto N. Witt, is shown.

8. A specimen of sulphate of ammonia as obtained from the products condensed from the blast furnaces of the Gartsherrie Iron Works is shown, and also specimens of the tar and various hydrocarbons extracted from it by Watson Smith, both paraffins and members of the benzine series.

9. In order to prepare naphtha and acetic acid from wood, the latter must be submitted to a destructive distillation at a comparatively low temperature. Oak cropwood is used for this purpose, and the distillation takes place in cast or wrought iron retorts. Specimens of oak cropwood such as is actually charged into the wood retorts, and of charcoal left as a residue, are exhibited, and besides these, specimens of crude tar and acid, and also of the purified products, are shown. It is generally said that pure commercial methyl alcohol made from wood must be obtained from Germany, as it is not prepared in this country. However, a specimen is shown here of a pure product made by a Glasgow firm for the use of dye and color makers.

10. An exceedingly fine specimen of the Boghead cannel coal, now quite extinct, but from which Dr. James Young first prepared paraffin, is shown, with one of the Boghead shale at present used, and a collection of naphthas, burning oils, paraffin waxes, etc., prepared from the Scotch shale.

In a horizontal case are shown specimens of raw cotton in the pod, and even with the pod attached to the branches from the cotton tree, raw picked cotton, cotton silk of various kinds in the pod and picked, raw jute and jute fibers, China grass, various dyewoods, several species of indigo plant and coloring matter, with seeds of the *Indigofera tinctoria*. On the outside of the case the entire trunk of a cinchona tree is shown; also a set of cinchona barks, collection of twenty commercial gums, one of resins, and specimens of seed, stick, and shell lac; Chinese insect wax, nutmeg in shell and fruit, cocaine plants and fruit, with active principles.

An interesting set of specimens illustrating the phosphate trade, and consisting of fine specimens of coprolites, apatites, etc., from the United States, is exhibited. Finally, a Chinese opium-smoker's tray is shown, with pipe and all the apparatus of the opium slave. Opium consisting of large balls, the commercial form, is also exhibited.

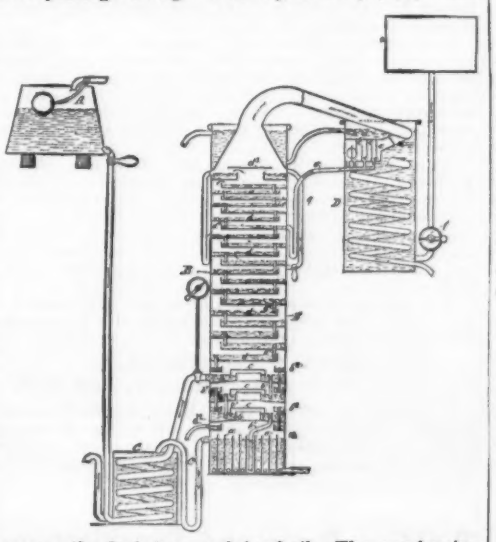
Henry Newall & Sons, 10 Marsden Street, Manchester (782), exhibit wood pulps prepared by mechanical and by chemical processes for the manufacture of paper; also wood flour, used in making linoleum, wall decorations, and other fabrics, and in the manufacture of explosives. A special feature in the exhibit is the chemically prepared wood pulp, which shows a fiber much longer and stronger than that prepared by the mechanical process. The manufacture of wood pulp was commenced in Norway about the year 1870, from 500 to 600 tons being exported in that year. The industry has increased very rapidly, the production last year being about 100,000 tons. At first the wood pulp made by the mechanical or grinding process, and possessing very little fiber, was the only kind produced, but within the last few years chemical processes have almost superseded this method. By treating the wood with sodium sulphite a pulp with a long fiber suitable for better class papers is obtained, while mechanical pulp is only used for newspapers, wall papers, etc. A large amount of wood pulp is produced in Germany, but it is mostly consumed there, very little being exported. It is estimated that last year the production of this article amounted to 150,000 tons, valued at about £350,000.

(To be continued.)

DISTILLING AND MATURING ALCOHOLS.

J. WALLACE, London.

THE object of the apparatus is the production of alcohol free from fusel oil and acetic acid, the absence of which is the characteristic of spirit which has been "aged," and an increased yield from a given quantity of grain, which the patentee states amounts to about 10 per cent. A is the wash charger feeding the wash continuously through the heater, C, kept full of spent wash, to the still column, B. The lower part of the still column is formed into a boiler, *a*, heated by a steam coil lying between the convolute partitions. *b*, *b*, *b*, are the distilling trays, each consisting of an annular space connected to the next tray lower by overflow pipes, b^1. C is a baffle, preventing the steam and vapor from passing through the center of the still without passing through the wash on the trays, *b*. *d*, *d*, *d*, are the rectifiers, charged at the begnining of an operation with cold water. They communicate with each other by an overflow pipe, and compel the vapors to follow a circuitous path. The fusel oil condensing on the rectifiers finds its way to the rings, b^2, at the lower part of the still and out by the pipe, d^3. D is the condenser in which the rectified and pure spirit is finally condensed, after passing through a baffle plate-box, *e*, *e*, *e*, which



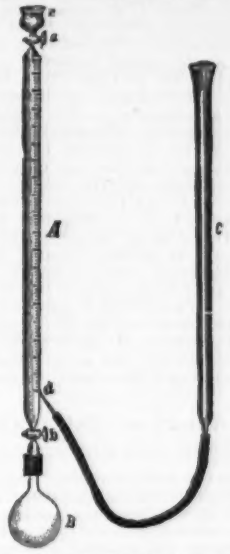
removes the last traces of fusel oil. The condensing water is supplied to D from an overhead cistern through a regulating valve, *f*. The quantity of water supplied to this vessel regulates the purity or "age" of the finished spirit.

ESTIMATION OF METALLIC IRON IN SLAG.

G. NEUMANN.

THE two methods at present in use for the estimation of metallic iron, mixed with iron compounds, are: (*a*) Digestion with $HgCl_2$, and titration of the ferrous chloride produced, with $KMnO_4$. (*b*) Digestion with $CuSO_4$, weighing the separated copper, or titration of the residual $CuSO_4$. The first method is liable to give too high results, the second, though very exact, cannot be employed when other bodies which decompose $CuSO_4$ are present. Both methods require a great expenditure of time.

The method employed by the author, while quite as exact as the above, has the advantage of being more rapid and generally applicable. The process consists in measuring the hydrogen evolved when the slag is treated with acid. This can be effected in a Lunge's nitrometer, but more conveniently with the apparatus figured. The flask, B, of 50–100 c. c. capacity, containing the material and nearly filled with water, is con-



nected by India rubber tubing to the graduated tube, A, of about 80 c. c. capacity and 1 cm. wide. Water is poured through the tube, C, into B till the cock, *b*, is filled. The latter is now closed, and the cock, *a*, being open, the tube, A, is filled with acid through C. After closing *a*, *b* is opened and the acid allowed to mix with the water in the flask. On warming the hydrogen is given off, collects in A, and after the apparatus has cooled, it is measured and its volume corrected for temperature and pressure. If the hydrogen evolved contains CO_2 or H_2S, they can be removed by allowing some caustic potash to run in from the funnel, *c*. The apparatus is also very serviceable for the estimation of metallic zinc in zinc dust or of CO_2 in carbonates.

ORSAT'S APPARATUS.

IN order to allow the copper spirals and capillary tubes in this apparatus to be readily removed when required, as well as to facilitate the washing out of the

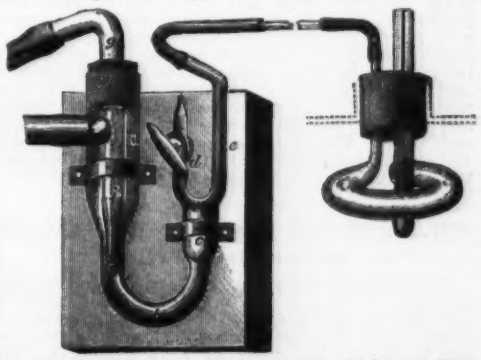
apparatus, C. Heintz has fitted the vessel, A, with a well ground and air tight stopper, thus avoiding the necessity of renewal of the vessel due to the spirals getting burnedor to the breaking of the capillary tubes.

A THERMOSTAT.

L. RUGHEIMER.

THE apparatus consists of a glass tube, *a*, with thick walls (see figure) to which a side tube, *h*, is attached and also a narrower U-tube, *b*, opening into a wider tube, *c*. The latter terminates on one side in a tube and simple glass stop cock, *d*, on the other side in a narrow thick walled tube, *e*, with a knee-shaped bend. The tube, *g*, is fixed in *a* by means of a cork and is drawn out toward *f*, and cut off at an angle. The tube, *g*, is also perforated at *i*. The mercury placed in *b* is just in contact with the open end of *f*. When the gas tap is open, gas passes through *g* and *f*, and then through *h* to the heating apparatus.

If the tap, *d*, is now closed and the temperature of the air bath raised, the mercury will rise and partly close the aperture at *f*. The total extinction of the



flame is prevented by the hole at *i*, which supplies a constant stream of gas to the flame. The apparatus used in connection with an air bath for eight sealed tubes has the following dimensions: *f* has a diameter of 5 mm. and walls 0·75 mm. thick, and *b* a diameter of 8½ mm. The mode in which the apparatus is regulated requires no detailed description. The tap, *d*, is gradually closed as the required temperature is reached; or, better still, the tap is closed completely several degrees below the point required, the temperature allowed to become constant, the tap again opened and quickly closed, and this operation repeated once or twice.

ZINC-COPPER AND TIN-COPPER ALLOYS.

By A. P. LAURIE.

THE author finds that if the zinc plate of a Daniell cell be replaced by a compound plate formed by joining copper and zinc, the cell has the same electromotive force as one in which zinc alone is used. This is true, even though the zinc surface be only 1-1000th part of the copper surface. If the zinc plate be replaced by copper-zinc alloys, no deflection of the electrometer is observed as long as the alloy contains less than 67 per cent of zinc. At this point, however, a big deflection, practically equivalent to that given by zinc, is suddenly obtained. This result, in the author's opinion, may be taken as evidence of the existence of a compound of the two metals of the formula $CuZn_3$. Alloys containing a greater proportion of zinc behave like zinc alone. Similarly in the case of tin-copper alloys, a sudden rise of electromotive force is observed when the proportion of tin in the alloy exceeds that which would be contained in a compound of the formula Cu_3Sn. This result is in harmony with the evidence already obtained by observations of the density and thermal and electrical conductivity of the copper-tin alloys. If an alloy containing a larger percentage of tin than Cu_3Sn, in a state of fine division, be placed in a copper cup and used in place of the zinc in a cuprous chloride cell, the excess of tin is gradually eaten out, leaving approximately the alloy Cu_3Sn. This alloy undergoes no change if the circuit be kept closed.

THE GREAT ALPINE ROCKFOIL.

(SAXIFRAGA PYRAMIDALIS.)

As shown in the accompanying woodcut, this plant is one of the most useful and beautiful that could well be grown, and all who possess a garden, however small it may be, can have this floral pyramid in the greatest perfection without the assistance of artificial heat of any kind. In Dr. Engler's monograph of Saxifrages this plant is put as a synonym of S. cotyledon. Although long considered in gardens as a distinct variety of that species, I am still of the opinion, after having

THE GREAT ALPINE ROCKFOIL.
(*Saxifraga pyramidalis.*)

seen them growing together for the past ten years, that the two are quite different. I have had wild plants of S. cotyledon from Norway and the Pyrenees, and they are quite different from this gigantic S. pyramidalis. The latter throws up large spikes 2 feet to 3 feet in height, thickly covered with white, rose-spotted flowers, forming a most charming pyramid, very useful in the decoration of the greenhouse and the conservatory. It is biennial so far as that the rosettes producing the flowers die when the season is over, but previously from the base of these old crowns are produced from six to a dozen or more of young ones ready to take their place the next year. When the plant is used for indoor decoration, these young crowns are taken off and potted in good rich compost, grown on in a cool north house or frame and shifted as required until finally they reach the pots in which they are intended to flower. When the plants become pot-bound, a weak solution of liquid manure will be found beneficial. On the rockery the plants require to be planted annually, and new soil should be given them when this takes place. Six inches apart will be abundant, and if healthy and vigorous, the plants will very soon almost meet each other. They make a pretty group in the open, and are much appreciated by those who have only seen the wild species on the Alps.—*The Garden.*

THE PRIMITIVE SEAT OF THE ARYANS.*

By Canon ISAAC TAYLOR.

THE author discussed recent theories as to the region in which the Aryan race originated. The pre-scientific Japhetian theory and the Caucasian theory of Blumenbach have long been abandoned. A few years ago the theory advocated by Pott, Lassen, and Max Muller, which made the highlands of Central Asia the cradle of the Aryans, was received with general acquiescence, the only protest of note coming from Dr. Latham, who urged that the Asiatic hypothesis was mere assumption, based on no shadow of proof.

The recent investigations of Geiger, Cuno, Penka, and Schrader have brought about an increasing conviction that the origin of the Aryan race must be sought, not in Central Asia, but in Northern Europe. These writers have urged that the evidence of language shows that the primitive Aryans must have inhabited a forest clad country in the neighborhood of the sea, covered during a prolonged winter with snow, the vegetation consisting largely of the fir, the birch, the beech, the oak, the elm, the willow, and the hazel; while the fauna comprised the beaver, the wolf, the fox, the hare, the deer, the eel, and the salmon—conditions which restrict us to a region north of the Alps and west of a line drawn from Dantzic to the Black Sea.

It has also been urged that the primitive Aryan type was that of the Scandinavian and North German peoples—dolichocephalic, tall, with white skin, fair hair and blue eyes—and that those darker and shorter races of Eastern and Southern Europe who speak Aryan languages are mainly of Iberian or Turanian blood, having acquired their Aryan speech from Aryan conquerors. It has been urged that the tendency in historic times has been to migration from north to south, and that in Central Asia we find no vestiges of any people of the pure Aryan type, while the primitive Aryan vocabulary points to the fauna and flora of Northern Europe rather than to that of Central Asia.

But the Aryans must have had forefathers from whom they were developed; and the inquiry suggests itself, What could have been the race from which the Aryans might have been evolved? A Semitic, an Iberian, an Egyptian, a Chinese, a Turkic, or a Mongolian parentage is out of the question; and the author proposed to show that both from the anthropological and the linguistic point of view the Finnic people come closest to the Aryans, and are the only existing family of mankind from which the Aryans could have been evolved. The Tchudic branch of the Finnic family approaches very nearly to what we must assume to have been the primitive Aryan type.

The only argument for deriving the proto-Aryan from Central Asia was the belief that Sanskrit comes the nearest to the primitive Aryan speech. It is now believed that the Lithuanian, a Baltic language, represents a more primitive form of Aryan speech than Sanskrit, and hence the argument formerly adduced in support of the hypothesis that the Aryans originated in Central Asia becomes an argument in favor of Northern Europe.

If this hypothesis as to the primitive identity of the Aryan and Finnic races be established, a world of light is thrown upon many difficulties as to the primitive significances of many Aryan roots, and the nature of the primitive Aryan grammar. We are furnished, in fact, with a new and powerful instrument of philological investigation, which can hardly fail to yield important results. Comparative philology must henceforward take account of the Finnic languages as affording the oldest materials which are available for comparison.

* Proceedings British Association.

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